Curtin University Sustainability Policy Institute
School of Design and Built Environment

Redefining the Smart City: Culture, Metabolism and Governance
Case Study of Port Louis, Mauritius

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AUTHOR'S DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Zaheer Allam

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STATEMENT OF CONTRIBUTORS

All the written materials submitted as part of this PhD by Publication, were conceived and coordinated by Zaheer Allam, who also undertook the majority of the writing and analysis for each of the eight publications.

Signed detailed statements from each co-author, relating to each publication are provided as appendices at the back of this thesis (Appendix A).

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ABSTRACT

Smart Cities are increasingly hailed as the potential solution for growing urbanisation, coupled with the demanding needs of efficiency and performance. Nonetheless, the Smart City paradigm is still evolving. However, it seems to be a branding or marketing competition between ICT consortiums where the key focus is implementation of their smart technologies. This is perhaps the reason why it is not being adopted or even used by the United Nations. There is a conspicuous gap in knowledge when it comes to understanding how the promised efficiencies of Smart Cities can lead to a range of desired outcomes such as the Sustainable Development Goal 11 referring to 'inclusive, safe, resilient and sustainable' cities including issues of cultural heritage. Smart Cities appear to be focusing on modernist development in green-fields sites. Moreover, there are issues with emerging cities if their priority to emphasise Smart Cities is not given adequate economic transparency.

This thesis attempts to resolve some of these issues through developing a new Smart Cities Framework and applying it through a case study on Port Louis, Mauritius. The Government of Mauritius has implemented a Smart Cities policy since 2014 which enabled the creation of nine new Smart Cities around Port Louis with a range of positive and negative impacts; the case studies can thus enable perspective to be generated on the Smart Cities concept.

The PhD consists of eight publications, supported by an Exegesis. Publication 1 examines the concept of Smart Cities through literature review and analysis developing a new Smart Cities Framework based around dimensions of Culture, Metabolism and Governance. This is then applied in eight papers that examine these dimensions in Port Louis.

Publication 2 focuses on the Cultural dimension of Smart Cities. It showcases how culture can promote inclusivity within diverse communities and be an effective driver for sustainable urban development. The paper further underlines how culture can encourage economic and social urban regeneration through cultural and creative industries and at the same time promote liveability within cities.

Publication 3 also pursues how urban regeneration can enable the Cultural dimension of Smart Cities by using new technology. It adopts a focus group methodology from key professionals from both the Public and Private sector and outlines avenues for sustainably regenerating the

city while supporting smart infrastructure to enable a healthy competition with emerging new Smart Cities in greenfield locations.

Publication 4 focuses on the Metabolism dimension of Smart Cities. It examines the theory developed by Newman (1999) of the Extended Metabolism Model which optimises metabolic flows (resource consumption and waste disposal) along with the improvement of liveability (economic and social wellbeing). It applies this conceptually to Port Louis. The importance of better models of governance in the form of integrated policies are also underlined in order to achieve these sustainability outputs.

Publication 5 continues the Metabolism dimension by suggesting how to effectively implement the Extended Metabolism Model by regulating the material flows in and out the city. The concepts of net-zero carbon city and zero-waste city are proposed to reduce wastage of energy, materials and water to increase liveability of cities.

Publication 6 further explores the Metabolism dimension by examining climate change mitigation strategies and underlines targeted policies in local guidelines that require change in order to ensure a sustainable and resilient city. The paper applies these to Port Louis. Resilience is further associated as a key dimension to assure adequate liveability standards in the context of a Small Island Developing State.

Publication 7 examines the Governance dimension of Smart Cities. It explores the theoretical application of the Smart City concept and shows how Smart City technologies can help human centric models by using digital infrastructure and big data through effective governing policies that shape human outcomes. The ideas are applied to Port Louis.

Publication 8 further develops the Governance of Smart Cities by building from the findings of the 7 published papers above and proposes an 'Urban Regeneration Scheme' based on integration of the three dimensions of Culture, Metabolism and Governance. It applies this to Port Louis. An econometric forecasting based on the application of the scheme showed positive results for private investment, public revenue, and jobs creation in Port Louis.

The findings of this PhD, based on the above 8 papers, seeks to bridge the gap in knowledge towards depicting the Smart City paradigm under a more focused set of outcomes that build towards better cities as suggested by the UN Sustainable Development Goals. It enables this to

be drawn together by the integrated dimensions of Culture, Metabolism and Governance as a Smart Cities Framework. Moreover, this study offers policy makers with substantial data in relation to the rejuvenation and revamping of the capital city of Mauritius based on the application of the new Smart Cities Framework. Its application to other emerging cities is developed from this analysis.

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LIST OF PEER REVIEWED PUBLICATIONS INCLUDED AS PART OF THIS THESIS

1. **Allam, Zaheer** and Newman, Peter. 2018. "Redefining the Smart City: Culture, Metabolism and Governance." Smart Cities (1): 4-25. *(Published)*

2. Siew, Gaetan and **Allam, Zaheer**. 2017. "Culture as an economic driver for sustainable development.'' UIA 2017 Seoul World Architects Congress. *(Published)*

3. **Allam, Zaheer**. 2018. 'Identified nodes for Smart Urban Regeneration. Focus group findings from the city of Port Louis, Mauritius.' Journal of Urban Regeneration and Renewal. *(In Press)*

4. **Allam, Zaheer**. 2017. "A theoretical application of the Extended Metabolism Model in Port Louis in a bid to promote urban sustainability." International Conference on Energy, Environment and Climate: 323-334. *(Published)*

5. **Allam, Zaheer**. 2018. "Towards a Zero Waste City. Case study of Port Louis, Mauritius." International Journal of Sustainable Building Technology and Urban Development (9): 110-123. *(Published)*

6. **Allam, Zaheer** and Jones, David. 2018. "Promoting resilience, liveability and sustainability through landscape architectural design: A conceptual framework for Port Louis, Mauritius; a Small Island Developing State." IFLA World Congress Singapore 2018 e-proceedings: 1598-1610. *(Published)*

7. **Allam, Zaheer**. 2017. "Building a Conceptual Framework for Smarting an existing city in Mauritius: The case of Port Louis." Journal of Biourbanism (4): 105-123. *(Published)*

8. **Allam, Zaheer** and Newman, Peter. 2018. "Economically incentivising Smart Urban Regeneration. The case of Port Louis, Mauritius." Smart Cities (1): 53-74. *(Published)*

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CO-AUTHORSHIP STATEMENTS

A signed statement summarising and clearly identifying the nature and extent of the intellectual input by the candidate and co-authors, where applicable, are featured in the appendix of this thesis.

OTHER RELEVANT PUBLICATIONS (NOT SUBMITTED AS PART OF THIS THESIS)

PEER REVIEWED PUBLICATIONS

1. Allam Zaheer. 2012. "Sustainable Architecture: Utopia or Feasible Reality?" Journal of Biourbanism (2-1): 47-61.
2. Allam Zaheer and Elahee M.K. 2014. "Exploring the Urban Heat Island effect in Port Louis, Mauritius." University of Mauritius Research Journal (20): 138-153.
3. Allam Zaheer, Dhunny A. Zaynah, Siew Gaetan, Jones S David. 2018. '' Towards Smart Urban Regeneration: Findings of an Urban Footprint Survey in Port Louis, Mauritius.'' Smart Cities 1: 121-133.
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BOOK CHAPTER

13. **Allam, Zaheer** and Jones, David. 2018. “Urban Heritage in the Indian Ocean Waters: Challenges of Urban Heritage Custodianship for Comoros, Maldives, Mauritius, Mayotte, Réunion and Seychelles.” The Routledge Handbook on Historic Urban Landscapes of the Asia-Pacific. *(Forthcoming)*

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14. Allam, Zaheer. 2012. “21st century Architecture: the desertion of ethos and the promotion of irrationality?” City Vision.
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EXEGESIS

CHAPTER 1 – INTRODUCTION

This thesis is based on eight peer-reviewed papers, where each address a specific research question that together forms a comprehensive study. The Exegesis part of the thesis explains the key background behind the rationale of the study while also highlighting the collective aim, literature review, methodology, results, discussion and conclusion. This section of the Exegesis offers insights on the background information of the topic under scrutiny while highlighting previous research. Moreover, the justification of the study is provided followed by the aims and objectives. The research significance and the structure of the thesis are then explained.

1.1 BACKGROUND

The world is witnessing an unprecedented increase in urbanisation. 55% of the world population lives in cities and this figure is expected to rise to 68% by the mid of this century (UN, 2018). However, certain cities in Asia and Europe have witnessed a decrease in urban population, principally due to low-fertility, poor economic situation and natural calamities (UN, 2018). Cities remain highly unsustainable across the globe (Newman, Beatley and Boyer, 2017) and are generally associated with negative contributions to ecological damage in their bioregion leading to social unrest and failing economies in the long term (Loorbach and Shiroyama, 2016). Cities use 80% of the world's resources (Bulkeley and Betsill, 2005) and are the main contributors to global carbon dioxide emissions (Swyngedouw, 2016, Mehaffy, 2017). There is a need for a more sustainable paradigm shift, in urbanisation. To this end, various authors postulate for the necessity for a deeper cultural, infrastructural and mind-set change, in cities that focus on the very nature of sustainability (Grin et al., 2010, W. et al., 2010, Mehaffy, 2017, Mehaffy, 2018, Salingaros, 2008, Salingaros, 2000, Salingaros and Masden, 2006, Alexander, 1987, Alexander, 2002). Literature points to a novel approach to urbanisation that could help solve such sustainability issues pertaining to enhanced movement towards urban areas, the Smart City paradigm (de Jong et al., 2015, Herrschel, 2013, Yigitcanlar and Lee, 2014). This concept is being scrutinised, among other urbanisation approaches, as a potential urban regeneration strategy (de Jong et al., 2015, Purnomo and Prabowo, 2016). It is also being acknowledged as the positive solution for a range of other ailments associated with urbanisation (Burte, 2014, Paroutis et al., 2014, Shelton et al., 2015).

Despite its frequent appearance in literature dealing with urbanisation issues, there is no universally accepted definition for Smart City (Albino et al., 2015, Burte, 2014, Chourabi et al., 2012a). Caragliu et

al. (2011) reviewed the Smart City paradigm and built upon the findings from a Vienna University of Technology on the same topic to propose a definition for Smart City. Their definition is based on six pillars: (i) smart economy, (ii) smart mobility, (iii) smart environment, (iv) smart people, (v) smart living and (vi) smart governance. Integrating the essence of these key dimensions together, yielded a definition that a Smart City occurs when "*investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (Caragliu et al., 2011)*. Nonetheless, the key dimensions of Smart City, vary considerably in literature (Mosannenzadeh and Vettorato, 2014b, Neirotti et al., 2014, Petrolo et al., 2017). The three most common ones are: smart governance, smart people and smart infrastructure (Balakrishna, 2012a, Chourabi et al., 2012a, Mosannenzadeh and Vettorato, 2014b, Nam and Pardo, 2011b, Neirotti et al., 2014).

It should be noted that the Smart City paradigm is most popularly associated with newly built Smart Cities (Allam and Newman, 2018b). However, Smart City initiatives are in the majority aimed at erecting new cities from greenfields and are designed in isolation without consideration of contextual cultural dimensions (Bosch, 2017). This absence of a broader understanding of how cities work can trickle down to loss of liveability (Mehaffy et al., 2014, Salingaros, 2000, Salingaros, 1999), businesses and cause cultural erosion in the rest of the city (Allam, 2018). Newly built Smart Cities are seen as unaffordable and unattractive, and can even be slowly abandoned (Angelidou, 2014). This may be due to their support of modernist urban and architectural language, which has been observed in various works of literature, to defy liveability concepts (Salingaros, 2008, Salingaros, 1998, Salingaros, 2000, Salingaros and Masden, 2006, Mehaffy et al., 2014).

Perhaps the biggest question mark around the concept of Smart Cities comes from a conspicuous silence from the United Nations with respect to the role of Smart Cities in solving urbanisation problems. At no stage in any of the Sustainable Development Goals or The New Urban Agenda is there any mention of the Smart Cities paradigm. In the cities SDG (number 11) the UN lays emphasis on the need to build 'inclusive, safe, resilient and sustainable cities' but in none of the following actions and indicators is there reference to Smart Cities. This suggests that the Smart City paradigm is seen as simply a branding war spearheaded by leading ICT-based consortiums seeking profit making as their primary or major motivation. This thesis addresses whether, due to the substantial adoption of Smart City by policy-makers, it may be possible to shift the use of this paradigm into the much bigger UN agenda.

There is some literature supporting such an approach. For example, Shelton et al. (2015) postulate that the potential application of smart technologies to existing cities, rather than building new ones as has been happening. Other studies urge policy makers to develop collaborative governance revolving around better public-private partnership and citizen participation for use of smart infrastructures aiming at more sustainable and liveable cities (Angelidou, 2014, Paskaleva, 2009, Sassen, 2011, Shelton et al., 2015, Townsend et al., 2010). This literature is built on to demonstrate how such actions can be co-ordinated and directed into broader goals through the Smart City Framework.

The thesis also seeks to develop and demonstrate this Smart City Framework by applying it to urban development in the nation of Mauritius, in an attempt to illustrate the application of the Smart Cities Framework for an emerging nation. The Government of Mauritius announced the creation of Smart Cities in 2015 and several have been under development across the island since then. It should be noted, however, that the concept of Smart Cities is being used for new urban areas being developed on a minimum area of 17.1 Hectares, while accommodating core components abiding by the concept of 'Work, Live and Play' (Mauritius, 2018b). There is recognition that such an initiative may lead to the decay of existing fabrics and there is already the start of a drive from the Government of Mauritius to mitigate such effects (Mauritius, 2018a).

The Smart City Scheme proposed by the Government of Mauritius consists of a series of fiscal incentives that makes it highly appealing to investors (Mauritius, 2018b). However, no such scheme exists for the implementation of smart infrastructures, over existing cities, to achieve sustainability and to promote liveability within a culturally-rich environment (Siew and Allam, 2017). For instance, the capital city of Mauritius, Port Louis, has long been the major administrative centre of the island while harbouring the only trade port and hosting main businesses and government bodies (Siew and Allam, 2017). However, there is an imminent risk of businesses leaving Port Louis and setting up in highly incentivised new Smart Cities. This could have cataclysmic repercussions on the city's future. There will be a consequential decrease in municipal revenue and with it lesser resources to maintain and upgrade the capital city's infrastructure, leading to urban decay (Allam, 2018).

To this end, the study therefore seeks to address this gap in knowledge by reviewing and redefining the Smart City paradigm in light of bringing forward the pillars of culture, metabolism and governance, for an existing city. It will suggest that the application to the capital city of Mauritius is likely to have

benefit for many other nations and cities that are trying to address similar issues emerging from the blind adoption of the Smart City paradigm.

The Exegesis will explain the coherence among the eight peer-reviewed papers making the core of this thesis. Each paper tackles a specific research question or several questions, but pulled together, they offer a comprehensive and in-depth analysis of the Smart City paradigm for an existing city. The end-product is a theoretical conceptual Smart City Framework which is then applied to the capital city of Mauritius. Besides filling a gap in knowledge, the findings of this thesis also offers insights to urban policymakers on ways and means to integrate the need for economic resilience, social inclusion, cultural heritage and environmental sustainability in this digital era.

1.2 PREVIOUS RESEARCH IN THIS AREA

There have been many attempts to help define the concept of Smart City. Allam and Newman (2018b) outlines 13 Smart City definitions based on the review of (Chourabi et al., 2012b). The authors highlight that contradictions appear in the interpretation of what a Smart City is, and a proper definition is yet to be determined. Allam and Newman (2018b) further explored the key dimensions of Smart Cities through a review of existing Smart City Frameworks provided by various researchers (Petrolo et al., 2017, Nam and Pardo, 2011a, Chourabi et al., 2012b, Washburn et al., 2009, Dameri, 2012, Neirotti et al., 2014, Balakrishna, 2012b, Mosannenzadeh and Vettorato, 2014a).

What stands out is the overwhelming reliance on ICT or the smart infrastructure component of the different Smart City initiatives, or frameworks. However, it is recognised that each city type has unique inherent characteristics which call for different developmental agendas (Slavova and Okwechime, 2016). In an industry generating billions of dollars of revenue per year, this underlines the question whether the Smart City paradigm is not entirely a branding exercise to increase profit making, carried out by technology suppliers (Söderström et al., 2014). Nonetheless, some studies tried to infuse a citizen-centric Smart City development paradigm (Sadowski and Pasquale, 2015, Lee and Lee, 2014, Yonezawa et al., 2015, Degbelo et al., 2016, Kourtit et al., 2012), but the prominent ICT component attached to the Smart City paradigm is still seen as a pillar of the concept. There seems to be a two-pronged approach in Smart Cities research: some are geared towards revamping urban areas through an economic boost with hallmark dimensions of creativity, innovation and entrepreneurship (Kourtit et al., 2012, Nam and Pardo, 2011b, Caragliu et al., 2011), whereas other research opted for a more managerial approach and examined how governance and urban management can be enhanced

through application of ICT (Townsend, 2013, Kitchin, 2014). Kitchin (2015) critically reviewed studies on Smart City and acknowledged their essential conceptual and political contributions. However, four shortcomings of these writings were outlined by the author: (i) the apparent lack of genealogical studies of the paradigm, (ii) the use of 'one size fits all' rhetoric, (iii) not many researchers focused empirical studies and comparative studies for Smart Cities at different places and (iv) there is weak exchange and collaboration between the different stakeholders.

This underlines a gap in knowledge in relation to redefining the Smart City paradigm, whereby instead of focussing on ICT as a strategy in its own right with a trickle down into solving other problems, the ICT can be designed to specifically solve human, heritage and environmental problems. Thus, this thesis has been generated to help create a Smart City Framework that can do this.

From a Mauritian perspective, the Smart City paradigm is applied exclusively to new, highly incentivised cities, owned by private consortiums. The Government of Mauritius, through the Board of Investment BOI (2015b), proposed the Smart City Scheme Guidelines, which aim to support the vision of implementing Smart Cities in Mauritius. This scheme is inspired by the Investment Promotion Act and the Investment Promotion Regulations of 2015 (BOI, 2015b). According to the guidelines, the new cities need to be developed on land having at least an area of 21.105 hectares and should be built under the 'live, work and play' concept (BOI, 2015b), and such an endeavour is expected to boost the socioeconomic development of the Island (BOI, 2016). However, there are very few studies that have critically examined the implications of Smart Cities in Mauritius. Glasmeier and Nebiolo (2016) view Mauritius' vision for Smart Cities as '*utopian notions of the city on the hill*'. Although the authors expound on the socio-political background of the Island as being a relatively stable and prosperous community, they highlight that the quest to make the island a Smart City, through technological and green energy investment, is still at its initial stages. The authors fail to distinguish between new Smart Cities or existing cities and they rather view Mauritius as a big city rather than a state with several cities. Dhunny et al. (2016) did not venture into the Smart City paradigm, but rather assessed the viability of a wind farm to harness energy for a Smart City in the South-East Coastal Zone of Mauritius. Betchoo (2016) adopted a focus group approach from academic peers, to propose an alternative to the Smart City approach and recognises the need for a much better Framework to shift policy-making into more of the agendas suggested by, for example, the UN SDG 11. There is a call for more citizen-centric development, enhanced agricultural development and to redefine the role of the State and private sector in the Smart City project (Betchoo, 2016). Sahadut et al. (2015) also highlight the need for better partnership between the government and the private sector in Mauritius, calling for a

deeper understanding of the technologies needed for Smart Cities. These authors also suggest that although Mauritius can learn from the experience of other countries, there is still need for a contextual plan by integrating its citizens.

Thus, Port Louis in Mauritius appears to be a good site to demonstrate a new approach to the Smart City paradigm.

1.3 JUSTIFICATION OF THE STUDY

Cities are struggling to cater for enhanced economic growth, while responding positively to social and environmental agendas (Oksman and Raunio, 2018). This is the Sustainable Cities agenda or even the Resilient Cities agenda (Newman, Beatley and Boyer, 2017). However, while this agenda remains the core focus of the UN the Smart Cities agenda has arrived and as outlined in the papers in this thesis there is significantly more use of the term than either Sustainable Cities or Resilient Cities. Thus, there is a need to create a Framework that can use this new Smart Cities branding and fill it with some of the sustainability and resilience agendas that are far from complete and are in great need of attention. The thesis is therefore pursuing the tension and dilemma that exists between these different concepts of how cities need to approach their futures. At the moment they are competing for resources and creative planning and policy development.

Cities in Mauritius are no stranger to this tension and dilemma. With the mushrooming of privately owned Smart Cities across the island, businesses are relocating from existing cities to new Smart Cities. Such a practice can lead to urban decay as municipalities in existing cities struggle to maintain infrastructural and basic amenities due to the lack of income from business erosion. Studies pertaining to Smart Cities in Mauritius are scarce and there is none that proposes a conceptual framework which focuses on the need of the citizens, rather than on the ICT-based trickle-down economic drive.

The rationale behind the study, is to propose a theoretical framework for a redefined citizen-centric Smart City paradigm. In fact, there is a potential loophole in the Smart City paradigm as being simply the result of a branding war between consortiums, although there are undeniable literature-backed evidences that Smart City indicators within the city may lead to better urban outcomes as the trickle-down application of ICT is picked up at local level. There is a gap in knowledge for a developmental framework where hallmark features of the Smart City paradigm are used as the drivers for a better urban agenda in terms of culture, metabolism and governance (as detailed in the thesis papers) rather

than being what a city should seek just for the sake of ICT branding. The findings of this study strive to inform policy makers on the limitations of the current model used in Mauritius and to propose an alternative approach. The urban lab selected for this study, is the capital city of the Island, Port Louis. This city is chosen, as it is the oldest city of the island, and holds the only trade port. Moreover, Port Louis is a culturally diverse and historically rich city whose economic future and viability are in jeopardy due to the relative conspicuousness of new Smart Cities that are mushrooming within a 10-km radius from the main business area of the capital city.

1.4 RESEARCH QUESTIONS

The aim of this study is to redefine the Smart City paradigm to better address the Sustainable Development Goal 11 which calls for 'inclusive, safe, resilient and sustainable' cities. The overarching research question is:

1. How can Smart City be redefined from a branding competition to enable a more inclusive, safe, resilient and sustainable city?

Seeking an answer to this query opened avenues to a series of sub-questions which have been addressed through peer-reviewed publications, including journal articles and conference papers. Most of the following research questions overlap and answers to each of the set queries have been discussed in specific papers as shown in Figure 1. Nonetheless, one specific question that directly links to the above overarching research questions is:

1.1 How can this be applied to Port Louis, Mauritius, as a model Smart City in the emerging world?

To better shape the research fundamentals of this broad aim, insights gained through this research were applied to the capital city of Mauritius, Port Louis. This research query has been attempted in most of the publications through a survey of specific concepts in the various papers as depicted in Figure 1.

To move away from the mainstream literature of Smart Cities as being in greenfields based on modernist car dependent buildings, there has been an attempt to show how Smart City technologies can be redirected to broader social, economic and environmental objectives and to apply them in an existing city. This led to the third research question:

2. How can urban regeneration be achieved through the application of a Smart City Framework in an existing city?

To elaborate on this question, the three fundamental Smart Cities pillars of Culture, Metabolism and Governance have been scrutinised through specific sub-questions and addressed in several papers (figure 1). These sub-questions are:

2.1 How can culture be an effective driver to encourage an inclusive, safe, resilient and sustainable city?

2.2 How can the metabolism of cities be improved to encourage an inclusive, safe, resilient and sustainable city?

2.3 How can the governance of cities be improved to encourage an inclusive, safe, resilient and sustainable city?

To further ponder on each of these subtopics, research findings and proposals were applied to the capital city of Mauritius, Port Louis. The findings gathered through the specific papers relating to the above research questions underline the need for economic and social regeneration for existing cities. To this end, a final research question was generated:

3 How can the application of a Smart City Framework in an existing city help in social and economic regeneration?

This question sought to propose a Smart City Framework, applicable to existing cities, which can lead to enhance liveability through social and economic regeneration.

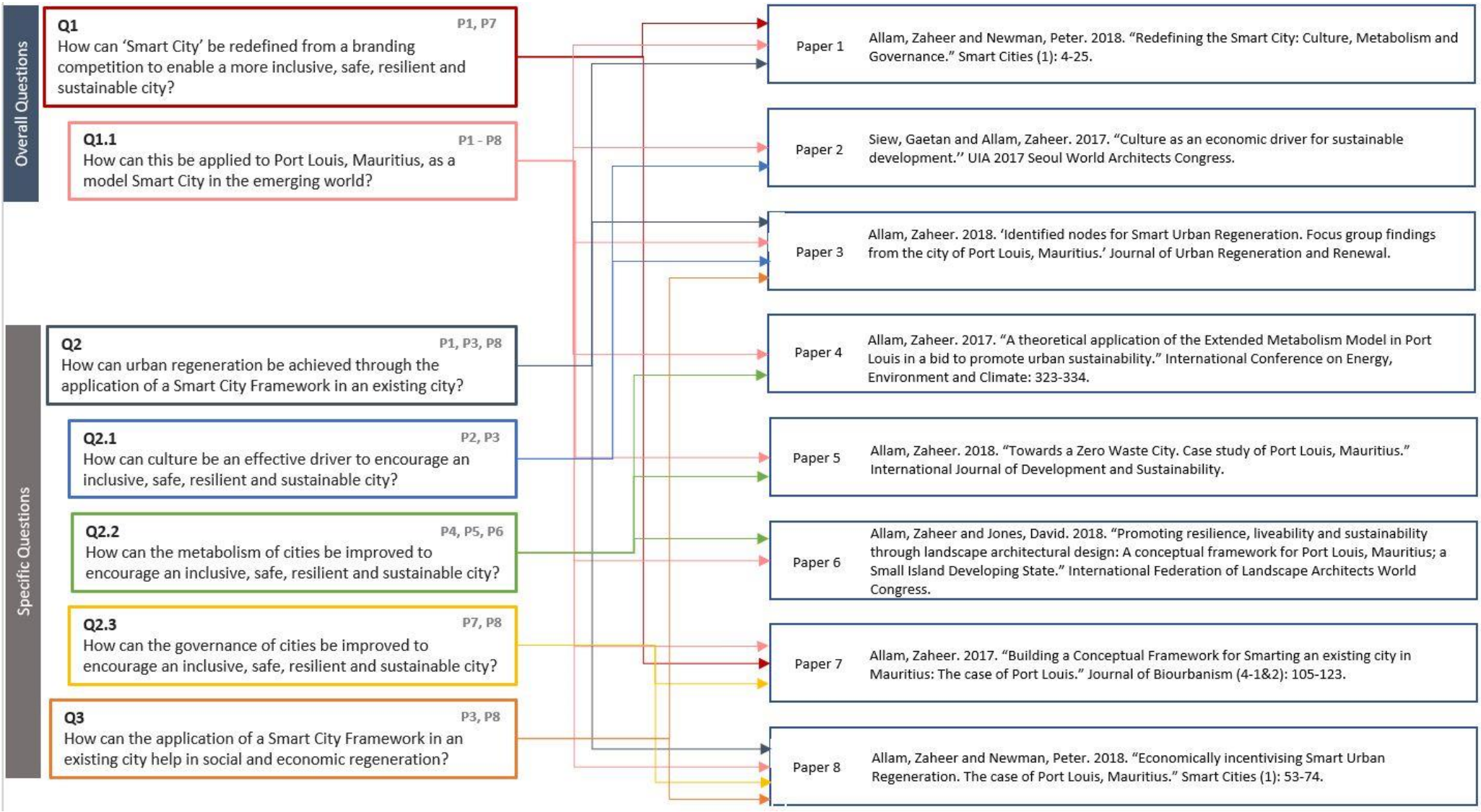

Figure 1. Relationship diagram showing research questions and related papers

1.5 AIMS AND OBJECTIVES

The main aim of this thesis is to redefine the Smart City paradigm to better address the hallmark features of the SDG 11 dwelling into 'inclusive, safe, resilient and sustainable' cities. This splits into the following objectives: -

- To review key definitions, dimensions and frameworks pertaining to existing Smart City paradigms.
- To identify potential gaps in knowledge in existing Smart City paradigms with respect to the SDG 11.
- To propose a new Smart City Framework better equipped for cities to reach the SDG 11.
- To understand how culture and urban heritage can drive sustainable development using ICT.
- To show how the metabolism aspects of cities can increase sustainability and liveability using ICT.
- To understand how governance can impact on socio-economic dimensions of cities using ICT.
- To apply the proposed Smart City framework and its hallmark dimensions to an existing city.

1.6 RESEARCH AND POLICY SIGNIFICANCE

This thesis contributes to knowledge and literature on the applicability of Smart Cities by developing a new Smart Cities Framework which attempts to link the focus on ICT to the broader UN agenda for cities. It does this in both an academic format and a policy format in the context of Mauritius as a typical emerging nation with the major city of Port Louis needing a much more extensive set of policy applications to enable it to grow into the future as a more inclusive, safe, resilient and sustainable city.

The findings from this study primarily leads to the development of a unique Smart City Framework but has clear applications into policy for any city. It has been applied to the City of Port Louis, by attempting to regroup dimensions of Culture, Governance and Metabolism and show how policy can be reshaped to achieve these broader goals by applying ICT. An Urban Regeneration Scheme, based on the findings from literature and that of a focus group, is then proposed to sustainably regenerate the urban fabric of Port Louis through tailored incentives that enable ICT to be shaped for broader goals. An econometric forecasting approach further applies the research into policy by quantifying the benefits of the proposed scheme in terms of attracting investment, revenue generation for the public sector and jobs creation.

Thus, the significance of this thesis is that it explores both a theoretical and academic agenda that helps redefine how any city can approach the future and provides a policy-based practical approach to the sustainable urban regeneration of the city of Port Louis. The Government of Mauritius adopted the recommendations of this thesis at national policy level as outlined in the conclusion.

1.7 STRUCTURE OF THE THESIS

The Exegesis provides an explanatory overview to this thesis. It includes a brief introduction (Chapter 1), a literature review on the context of the study (Chapter 2), a brief description of research methods adopted (Chapter 3), a summary of the eight publications (Chapter 4), results and discussions (Chapter 5), and conclusions with recommendations for future work (Chapter 6). Finally, the full publications are annexed with this Exegesis.

Chapter 1 has outlined a general understanding of the literature relating to the Smart Cities problem, the research questions and the objectives of the study.

Chapter 2 provides a literature review on the Mauritian context and a general overview on the adoption of Smart Cities in Mauritius, followed by a general overview of Port Louis.

Chapter 3 presents the rationale for the methodologies used to answer the research questions, as derived from the literature review and theoretical premises. It outlines the chosen data collection and literature review methods, followed by a description of the analytical frameworks used and developed in this research.

Chapter 4 presents a summary of each of the eight publications, presented in this study.

Chapter 5 presents an overview of the results and discusses the main findings of the study.

Chapter 6 presents the conclusions and recommendations for future research. It addresses the central issues set out in Chapter 1 and relates them to the overall research findings as well as the possibilities and directions for extending and broadening the research.

This research also contributes to sustainability and economic knowledge, and literature, by providing strong empirical pillars for discussion and a base for designing policies aimed for social and economic regeneration for emerging cities.

CHAPTER 2 – LITERATURE REVIEW

2.1 ACADEMIC LITERATURE

An extensive literature review, forming the natural extension of this Exegesis, has been performed and published in the first paper entitled: 'Redefining the Smart City: Culture, Metabolism and Governance.' This looks at the academic and theoretical basis of the concept and also shows how it is being applied in Mauritius. The sections below provide detail on Mauritius.

2.2 OVERVIEW OF MAURITIUS

Mauritius is a democratic Small Island Developing State (SIDS) located in the Indian Ocean, east of Madagascar. The nation is a series of small islands and forms part of the Mascarenes Island. Mauritius is hailed as a model of stability and economic resilience by economist Paul Collier who suggests this is due to the capability of Mauritius to shift economic policies due to its small size (Collier, 2006). This can also be attributed to the transition from a monocrop economy to a robust financial sector and tourism industry. The island has a culturally diverse population of 1.3 million inhabitants for a total area of 2,040 km^2. The official language is English, but the most spoken one remains Creole, with French and Indian languages also being quite popular. Hinduism is the major religion, but Christianity and Islam are also widely practised. It should be noted that the life expectancy of the inhabitants is one of the highest in Africa with 71 years for men and 78 years for women. From an economic perspective, Mauritius boasts one the fastest growing economies in Sub-Saharan Africa with real estate, manufacturing, transport storage and communications together with financial intermediation being the main drivers of GDP growth (Tandrayen-Ragoobur and Padachi, 2013). In fact, the key role of infrastructural development as a booster of economic growth, is reflected in the main theme of the 2017-2018 budget of Government of Mauritius. The budget lays emphasis on the upgrading of infrastructure to boost future development (GoM, 2017).

However, as per the World Risk Report of 2017, Mauritius is ranked 7^{th} and 13^{th} amongst the countries with highest exposure and highest risk respectively on a worldwide scale (Mucke, 2017). As a SIDS, Mauritius is in addition, on the forefront of the effects of climate change. These are already felt through events such as enhanced sea-level rise, prominent coastal erosion and a higher incidence of life-threatening weather phenomena like flash floods (JICA, 2016). According to JICA (2016), Mauritius is expected to face dire challenges in terms of sustainability for the years to come. For instance Mysiak et al. (2013) highlight that the average temperature has already increased by 0.74-1.1^oC since the 1961-90 and is expected to reach 2 ^oC by 2070. Furthermore, in the next 30 years, the island is

expected to face a decrease of 13% in utilisable water resources, which will be coupled with a drop in agricultural production by as much as 30%. Sea-level is expected to rise substantially, leading to a loss of beaches that will put the booming tourism industry into jeopardy. There is a need for remedial plans and a further consolidation of the economy to make Mauritius more resilient in the face of climate change.

There is also an enhanced urbanisation that has led to a range of issues for the island (Baguant-Moonshiram et al., 2013). Urban planning has been in use legally in Mauritius since the enactment of the Town and Country Planning (TCP) in 1954. Authors like Baguant-Moonshiram et al. (2013) support that the TCP helped to create a better framework for enhanced sustainability in Mauritius by integrating urbanisation is a key component of sustainable development but a review of the TCP shows no mention of sustainable development principles. The concept was much later adopted. While the Government of Mauritius mentions that Smart Cities have Sustainable development in mind (BOI, 2015a), researchers believe that the use of the Smart Cities paradigm to help produce more sustainable development has not been the agenda in Mauritius (de Jong et al., 2015, Herrschel, 2013, Yigitcanlar and Lee, 2014).

2.3 SMART CITIES IN MAURITIUS

In 2015, the Government of Mauritius announced the construction of 8 Smart Cities requiring USD 3.5 Billion in investment from the private sector. The vision was later re-branded as 'Smart Mauritius' (BOI, 2017), but it is noted that the introduced framework solely encourages the development of new cities (BOI, 2015a). These privately owned urban areas are economically incentivised (Table 1) and this strategy has been proposed by the government of Mauritius in a bid to boost socioeconomic development on the island (BOI, 2016). To meet such an end, this endeavour had as prime objective, a promotion of liveability and economic development through innovative practices and an introduction of novel technologies. Existing towns and villages on the other hand, face an increasingly hard competition against new emerging cities. Moreover, to encourage the rapid development of Smart Cities, the Government of Mauritius introduced a 'Smart Cities Scheme' hosting attractive fiscal incentives (BOI, 2015a). Fiscal incentives are practiced in Special Economic Zones (SEZs) in Mauritius and has proven to be a major booster of investment and jobs creation (Litwack and Qian, 1998, Ge, 1999, Farole, 2011). The set of fiscal incentives for Smart Cities, has witnessed similar success and

there has been an emergence of Smart Cities enhancing competitiveness for businesses while bolstering administrative functions of cities (Bunwaree, 2014).

1	A Smart City company (holder of SCS Certificate) is exempted from the payment of: (i) income tax for a period of 8 years from the issue of the SCS Certificate provided that the income is derived from an activity pertaining to the development and sale, rental or management of immovable property other than an activity in respect of the supply of goods and services (ii) land transfer tax and registration duty on transfer of land into the Smart City Company for the development of the Smart City project, provided that the transferor holds shares, in the Smart City Company, equivalent to the value of the land transferred. (iii) land transfer tax and registration duty on the transfer of land from a Smart City Company to a Special Purpose Vehicle (SPV) set up to develop a component of the Smart City project, provided that the Smart City Company holds shares in the SPV, equivalent to at least the value of land transferred (iv) land conversion tax in respect of the land earmarked for the development of non-residential components (office and business parks, ICT and innovation clusters, tourist, leisure and entertainment facilities including hotels and golf courses, renewable energy and green initiatives); (v) valued added tax in respect of buildings and capital goods (vi) customs duty on the import or purchase of any dutiable goods, other than furniture, to be used in the infrastructure works and construction of buildings under the Smart City scheme (vii) morcellement tax for the subdivision of land
2	A Smart City company issued with a SCS Certificate is granted accelerated annual allowance at a rate of 50% of the costs in respect of capital expenditure incurred on: (i) renewable energy (ii) energy-efficient equipment or noise control device; (iii) water-efficient plant and machinery and rainwater harvesting equipment and system (iv) pollution control equipment or device, including wastewater recycling equipment (v) an effective chemical hazard control device (vi) a desalination plant (vii) composting equipment (viii) equipment for shredding, sorting and compacting plastic and paper for recycling.
3	The Smart City Company may sell serviced land to another company to develop a component of the Smart City project.
4	Application for the permits and licenses submitted by the Smart City Company will be facilitated through the BOI One Stop-Shop and fast tracked through the Investment Projects Fast-Track Committee
5	Sale of immovable property can be made by way of 'Vente en Etat Futur d'Achevement' (VEFA) or 'Vente a Terme'
6	Land transfer tax for immovable property sold on VEFA is payable in four 6- monthly instalments

Table 1. Fiscal Incentives for investing in Smart Cities in Mauritius (Adapted from BOI (2015b)

Google Trends highlights that the concept of Smart Cities has gained in popularity in Mauritius. This is showcased in Figure 1, highlighting countries where searches about Smart Cities has been most conducted on the Google platform (Figure 2).

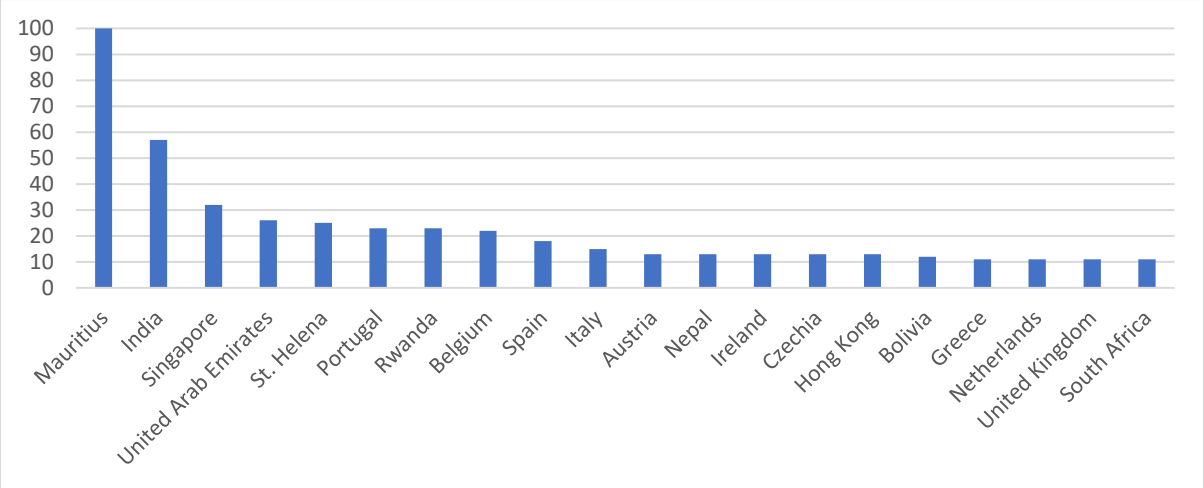

Figure 2. Countries with most searches for Smart Cities (Trends;, 2018)

There have been numerous projects falling under the 'Smart City Scheme'. One of the first urban developments to obtain the Smart City Certificate, is, the 'Mon Trèsor' Smart City in the south of the island, led by Omnicane Group (Omnicane, 2018), followed by the Moka Smart City (ENL, 2017). Numerous other projects are in the pipeline, but most of them are defined by their emphasis on creation of economic opportunities. Nonetheless, these projects are still in developmental stages.

It is conspicuous to note that within a 10km radius surrounding the Central Business District (CBD) of Port Louis, there are nine planned Smart Cities, five of which have already secured their approval from the Government of Mauritius (figure 3). The remaining four are under evaluation. This shows that there is an urgent need to consider the implication of mushrooming of new Smart Cities in Port Louis, the historical business centre of the island.

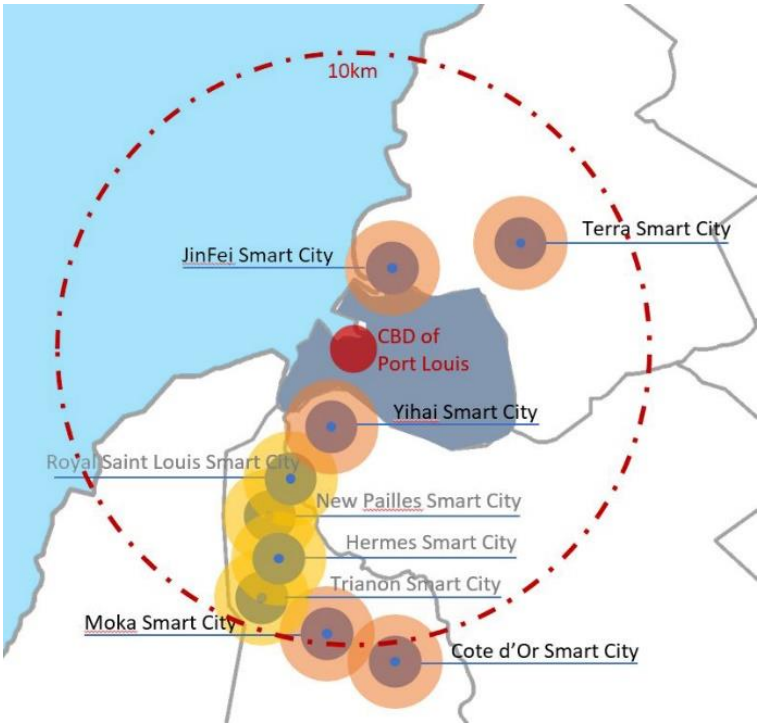

Figure 3. Smart Cities within a 10km radius from the Central Business District (CBD) of Port Louis

2.4 OVERVIEW OF PORT LOUIS

Port Louis is situated in the North West coastal side of the Island and is bounded inland by the Port Louis-Moka mountain range. Having an area of 46.7 km^2 for 119,333 inhabitants, as of December 2016), the capital city of Mauritius is the most densely populated district of the island with 2,954 P/km^2 (Statistics, 2017). Port Louis remains one of the most vibrant cities of the Island with a prominent historical and cultural dimensions infused within a multi-ethnic community (Ramkissoon and Nunkoo, 2011). Moreover, the capital city is the seat for major judicial and administrative instances of the state, such as, the Supreme Court, the Government House and the parliament. In fact, Port Louis is the seat for the only trade port of the Island and is responsible for handling more than 95% of the country's external trade (Narsoo et al., 2009). There is, nonetheless, the possibility of Port Louis losing its main administrative role due to changes in the administrative landscape of the island as a result of emerging technoparks and privately-owned Smart Cities (Bunwaree, 2014). Such a situation will challenge the economic and administrative sustainability of the city (Redaction, 2017).

From a historical perspective, when Mauritius was first colonised by the Dutch between 1638-1710, they established a harbour at the southern village, which they named 'Grand Port'. However, Port

Louis was the chosen ground for the capital city, as it hosted a naturally safe harbour in terms of its geography and terrain morphology (Nag, 2017). The Dutch named it Noordt Wester Haven and it was not until the French colonisation, that the city was named Port Louis. In fact, the French governor Bertrand François Mahé de Labourdonnais is considered by many historians, as the one who led the initiative to develop Port Louis as a major trade port (Toussaint, 1966). Nonetheless, the capital city of Mauritius faced dire challenges even in olden times. For instance, in the 18th and 19th century, there had been a series of fires, plagues and tropical storms, including bouts of malaria and cholera, that afflicted Port Louis (Macmillan, 2000). Nonetheless, the city showed great resilience and is nowadays viewed as one of the most important financial centres and Port Cities in Africa.

The urban planning for Port Louis was led under French colonisation from 1715-1810, and then under the British until independence in 1968. The French's approach was to favour large alleyways and to maintain a lush canopy. Their designed infrastructure satisfactorily sustained the Port Louis population of around 6,779 inhabitants in 1968. However, today, Port Louis accommodates a population of 155,226 (Stanford University, 2018), being a demographic increase of 2,290% over 50 years. The city witnessed this exponential increase in population without expanding its basic infrastructure services in many areas. Coupled with the effects of climate change, sandwiched by the Signaux Mountains, the Port-Louis Moka Range and the Indian Ocean, this rapid urbanisation has created concerns in terms of city planning.

The contemporary post-independence government's response to Port Louis' urban planning has been haphazard, with poor consideration to the historical and ecological dimensions of the city. Moreover, the national urban planning frameworks, favour car dependency and urban sprawl (Lands, 2011, Allam, 2013). This has led to a rapid reduction of the French established green areas and several historical buildings in the city. Today, one major hurdle to the proper development in the inner city, is essentially linked to a frozen rental price of property since 1962, following the devastating consequences of Cyclone Carol. The 'Landlord and Tenant Act' was enforced to prevent excessive rental rise from landlords during that time of crisis. However, property rental has been the same for 56 years (Kanaksabee, 2017). With no attractive revenue, this condition forces landlords to abandon their properties which slowly leads to an urban decay (Groëme-Harmon, 2018).

From a cultural perspective, Port Louis stands as one of the most culturally diverse cities in Mauritius, however that is defined (Throsby, 2001). Siew and Allam (2017) suggest two dimensions of culture that should be present in a broader definition: (i) culture being viewed as a set of attitudes, customs

and beliefs shared by a particular group, and (ii) culture as a series of activities related to intellectual, moral and artistic uplifting of human life. These key dimensions support a prominence of an economic perspective in culture. For instance, it is recognised that culture englobes key industries like cultural tourism and creative industries that are both viewed as the driver and enabler of key pillars of sustainable development (UNESCO, 2012, 2016). Throsby (2001) highlights the need to consider cultural heritage as one key driver of the city's economics. Such consideration puts forth the rich cultural capital that Port Louis represents in terms of centuries old historical buildings, paved roads, museums, forts and traditional and craft markets. In fact, the capital city has 81 sites that are listed as national heritage (MCCPL, 2016). Moreover, several culturally rich areas such as China Town, the Champ de Mars race course and the Aapravasi Ghat, are also found within the city's boundary; the latter being classified as a World Heritage Site by UNESCO (UNESCO, 2018). The cultural vibrancy of the city also manifests in intangible forms and contributes to the vibrancy of the urban fabric of Port Louis. These include gastronomy, crafts and entertainment activities (Bertacchini and Re, 2017). However, it has been noted that the maintenance and uplifting of these key cultural facets of the capital city of Mauritius will not only be a major economic boost for Mauritius, but it will help in the upgrading of the social fabric of the city (Bertacchini and Re, 2017). This converges with the viewpoint of Newman (1999) who supports the liveability of cities through human dimensions.

CHAPTER 3 - RESEARCH DESIGN AND METHODS

This chapter highlights the research philosophy and design adopted. It should be noted that each published paper has its own research design, but overall, the thesis adopted one overarching research philosophy: an interpretivist approach as it best suits the objectives of this study. The interpretivist advances that an inferred reality is accessible through social constructs by human actors and postulates that the enquirer uses their preconceptions to dictate the process of enquiry (Walsham, 1995). Moreover, the interpretivist researcher is expected to interact with human subjects which, even though, can lead to a change in perception among various parties (Creswell, 2007, Walsham, 1995), it caters for better contextualisation. This aligns with the researcher's stance on the Smart City paradigm as applied to the city of Port Louis in Mauritius. The adopted approach for this study moreoever uses an empirical methodology and is science based rather than literature interpretation.

Along the course of data gathering, there have been numerous communications between the researcher and key stakeholders for the city of Port Louis. In each of these communication instances, both parties had preconceptions prior to the interactions and these evolved after the meetings. The research design applied for this study, is that of a case study that constantly reflects back to the theoretical base and Smart Cities Framework that has been constructed. Case studies have been ubiquitously used in social sciences research despite no apparent consensus in relation to a proper definition for a 'case study' (Levy, 2008). Nonetheless, Levy (2008) postulated that case studies are much more than narratives in approach, and may involve statistical analyses. This merges with the qualitative and quantitative research design adopted in this thesis. This enables robust dealing with complex issues in terms of realism and contextualised meaning of a phenomenon (Miles et al., 1994).

3.1 SUMMARY OF METHODOLOGIES FOR EACH PAPER

The methodologies employed for each of the eight publications were detailed in the respective papers. This section (through table 2) provides a summary of the methods. It should be noted that some of the research questions overlap over several papers, but each paper adopts its own specific methodology.

	Paper	Questions Addressed	Theories used	Methodologies Used
1	Allam, Zaheer and Newman, Peter. 2018. "Redefining the Smart City: Culture, Metabolism and Governance." Smart Cities (1): 4-25.	1, 1, 1, 2	Smart City paradigms, SDG 11 and Sociotechnical Transition theory.	This study adopted an extensive literature review approach to explore the definitions and existing frameworks of the Smart City paradigm to create a new Smart City Framework.
2	Siew, Gaetan and Allam, Zaheer. 2017. "Culture as an economic driver for sustainable development.'' UIA 2017 Seoul World Architects Congress.	1.1, 2.1	SDG 11	This paper relied on a systematic review of literature involving an inclusion criterion based on the study theme to enable Culture to be expanded as part of the Framework.
3	Allam, Zaheer. 2018. 'Identified nodes for Smart Urban Regeneration. Focus group findings from the city of Port Louis, Mauritius.' Journal of Urban Regeneration and Renewal.	1.1, 2, 2.1, 3	Smart City Paradigms and Focus group approach	This paper pursued, through a focus group approach (from key professionals from both the public and private sector), the questions as how to achieve urban regeneration through each of the dimensions of the Smart City Framework.
4	Allam, Zaheer. 2017. "A theoretical application of the Extended Metabolism Model in Port Louis in a bid to promote urban sustainability." International Conference on Energy, Environment and Climate: 323-334.	1.1, 2.2	Extended Metabolism Model	This study applied the Extended Metabolism Model as a theoretical foundation to promote urban sustainability in Port Louis and how ICT can be used.
5	Allam, Zaheer. 2018. "Towards a Zero Waste City. Case study of Port Louis, Mauritius." International Journal of Development and Sustainability.	1.1, 2.2	Zero Waste City Model	This study reviewed and assessed the challenges and opportunities of key dimensions of the 'Zero-Waste' city paradigm for its potential application for the city of Port Louis.
6	Allam, Zaheer and Jones, David. 2018. "Promoting resilience, liveability and sustainability through landscape architectural design: A conceptual framework for Port Louis, Mauritius; a Small Island Developing State." International Federation of Landscape Architects World Congress.	1.1, 2.2	Landscape architectural design, Principles of ecosystem and SIDS	This paper dwelled on a theoretical application of the key dimensions of landscape architectural design to propose a conceptual framework to promote resilience, liveability and sustainability in Port Louis.
7	Allam, Zaheer. 2017. "Building a Conceptual Framework for Smarting an existing city in Mauritius: The case of Port Louis." Journal of Biourbanism (4-1&2): 105-123.	1, 1.1, 2.3	Smart City Paradigm SMART Model	This research builds upon existing frameworks for the Smart City paradigm and proposes a conceptual framework for the city of Port Louis based around the Smart Cities Framework.

8	Allam, Zaheer and Newman, Peter. 2018. "Economically incentivising Smart Urban Regeneration. The case of Port Louis, Mauritius."	1.1, 2.1, 2.3, 3	Smart City Framework, Smart Urban Regeneration Framework	This study builds on the findings of a focus group (paper 3) and proposes a Smart Urban Regeneration model leading to the socio-economic regeneration of cities. An Urban Regeneration Scheme is proposed and applied to the city of Port Louis. Results are quantified through the application of selected econometric forecasting models.

Table 2. Summary of methodologies for each paper

3.2 ANALYTICAL FRAMEWORK FOR THE RESEARCH

This study relied on several key theories, models and paradigms, in relation to urbanism and sustainable development, as analytical frameworks as outlined below:

3.2.1 THE SUSTAINABLE DEVELOPMENT GOALS

A major concern since the UN's Commission on Environment and Development in 1987 has been the need for sustainability and to that end, the United Nations' Sustainable Development Goals (SDGs) have been developed as an analytical and policy framework. The SDGs were launched in January 2016 after being agreed to by every nation on earth. They are meant to be delivered by 2030 and are expected to be a major guide for UNDP policy and funding as well as each nation having its own strategy (UNDP, 2018). There are 17 SDGs that act as a series of interlinking guiding principles for: (i) ending poverty, (ii) protection of the planet, and (iii) ensuring peace and prosperity for all people. For the needs of this study, the guiding principle set out as SDG 11, calls for cities and communities to be 'inclusive, safe, resilient and sustainable'. The aim of this SDG is the promotion of liveability in cities by making them greener, safer and more resilient to the ailments of climate change. Moreover, this SDG calls for a reduction in per capita environmental impact of cities through better municipal waste management, while also, laying emphasis on the need for better equity and transparency as well as sustainable cities through efficient planning and management. One other key element is the essential need for the safeguard of the world's cultural and natural heritage. As this is a UN agenda it does not use Smart City ideas, but it is possible to examine how ICT could in fact play a critical role in the achievement of all the SDG's, especially the city SDG, as attempted in this thesis.

3.2.2 THE EXTENDED METABOLISM MODEL

From a historical perspective, Wolman (1965) introduced the concept of urban metabolism. This paradigm builds on the biological meaning of metabolism and thus postulates a better understanding for materials input, processes and output in cities, so that metropolitan operations are optimised. Building from this model, Newman (1999) proposed an extended urban metabolism model which offers in-depth insights on materials flow, within the urban ecosystem but adds the dimension of liveability. The Extended Metabolism suggests that sustainability in cities can be envisaged as minimising resource inputs and waste outputs whilst increasing liveability at the same time. This

approach pinpoints potential loopholes in materials and energy flow in the city and thus can inform policy makers for better planning and regulation. The end focus is to promote liveability within the city whilst also dealing with metabolism. This concept makes cities more attractive and safer for the people as well as promoting community and city growth, and development of human capital while attracting investors (Newman, 2006, Giap et al., 2014). The potential for ICT to help with the Extended Metabolism Model has not been previously addressed in any of the literature around this concept as is set out in this thesis.

3.2.3 THE SMART CITY PARADIGM

This paradigm is ubiquitously used in urban literature, but holds no universally accepted definition (Neirotti et al., 2014). The Smart City paradigm revolves around the potential application of sensors in urban areas that communicate with one another through the concept of internet of things. The potential of big data further promotes better operational management in cities. This concept has been hailed as being the torch bearer of novel types of solutions, anchored in this digital era to solve urbanisation problems (Burte, 2014, Paroutis et al., 2014, Shelton et al., 2015). The assumed potential application for the Smart City paradigm, and demonstrated around the world, has been essentially focused on new cities with state of the art modernist facilities. Such examples include Masdar City in Abu Dhabi, PlanIT Valley in Portugal, and Songdo and Hwaseong Dongtan in South Korea, among others (Carvalho, 2014, Washburn et al., 2009). Nonetheless, there has been a call for adoption of these approaches to rejuvenate existing cities (Shelton et al., 2015). Other researchers have urged the Smart City paradigm to promote enhanced public-private partnership and better inclusive developments to promote a more liveable and sustainably enriched city (Angelidou, 2014, Paskaleva, 2009, Sassen, 2011, Shelton et al., 2015, Townsend, 2013). Thus, this thesis has used the Smart City paradigm to try and switch away from the modernist, green field or new city approach to city building but to see how it could be shifted to help traditional cities by rejuvenating older urban fabric.

3.3 RESEARCH MODEL RHETORIC

This pictorial representation (figure 4) of the research model depicts the overall layout of this study. The prime focus is on how to make 'inclusive, safe, resilient and sustainable' cities. Such a situation calls for remedial and mitigating approaches through key approaches such as: (i) a better understanding of urban metabolism, (ii) novel waste management strategies, (iii) sustainable economic opportunities, and (iv) enhanced liveable cities, all given new opportunities through the use of smart technologies. These key dimensions form the pillars of the Smart City paradigm. A particular focus is on how there is a valid Smart City Framework which can be applied not just to new privately-owned cities. The Smart City paradigm as developed by ICT companies revolves around the internet of things and big data narratives, but the research model as set out in the thesis and summarised in Figure 4, tries to make the focus much more on how the ICT can be raised to broader levels of the UN SDG 11. The proposed Smart City Framework is supported by the dimensions of culture, metabolism and governance. This Framework is then applied in various ways in the papers in this thesis to demonstrate what it could mean in practice and policy.

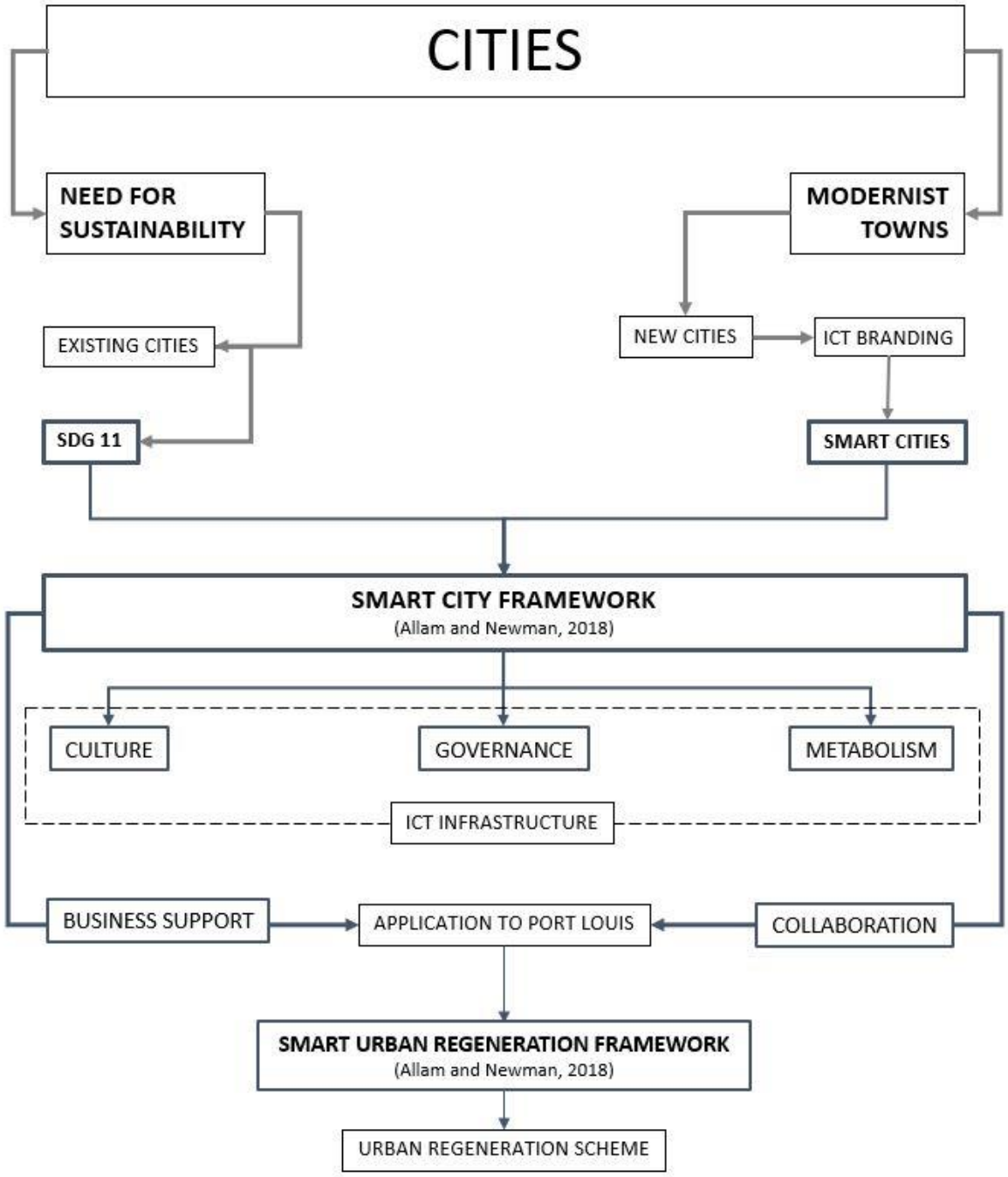

Figure 4. Research model

CHAPTER 4 - PUBLICATIONS

The eight publications highlighted in this Exegesis are featured in the annex of this document. Table 3 below showcases the findings and status of each of the publications. The adopted methodologies were outlined in Table 2.

Paper		Type	Publication Status	Findings
1	Allam, Zaheer and Newman, Peter. 2018. "Redefining the Smart City: Culture, Metabolism and Governance." Smart Cities (1): 4-25.	Journal Article	Published	A Smart City Framework with three pillars (Culture, Metabolism and Governance) have been identified which will pave the way for any city to reach sustainability. On application, there is a need to consider the implications of change through socio-technical transition theory to ensure an inclusive implementation.
2	Siew, Gaetan and Allam, Zaheer. 2017. "Culture as an economic driver for sustainable development.'' UIA 2017 Seoul World Architects Congress.	Conference Paper	Published	Culture has a prominent role to play as a driver for sustainable urban development. Culture can promote liveability through social inclusiveness and citizen participation in cultural, economic and social activities of cities.
3	Allam, Zaheer. 2018. 'Identified nodes for Smart Urban Regeneration. Focus group findings from the city of Port Louis, Mauritius.' Journal of Urban Regeneration and Renewal.	Journal Article	In Press	Six main themes emerged showcasing that dimensions of Collaboration and Business Support were required in addition to the 4 already identified; Culture, Metabolism, Governance, and Smart Infrastructure. The Metabolism aspect of cities was the most important theme as pointed out by factor of emphasis.
4	Allam, Zaheer. 2017. "A theoretical application of the Extended Metabolism Model in Port Louis in a bid to promote urban sustainability." International Conference on Energy, Environment and Climate: 323-334.	Conference Paper	Published	Key indicators have been identified for dimension of energy, water, waste and transportation for the city of Port Louis. These indicators need to be backed by appropriate policies to ensure an increase in liveability within the city. Liveability was seen as a major driver for urban sustainability.

5	Allam, Zaheer. 2018. “Towards a Zero Waste City. Case study of Port Louis, Mauritius.” International Journal of Development and Sustainability.	Journal Article	Accepted	Three indicators for effective and sustainable waste management were identified; socio-economic, political/institutional and technological. Moreover, each city has its own sets of attributes and waste-management protocols and hence one model cannot be adopted using a ‘one size fits all approach’. Key roles of governance were brought forward in the implementing of desired policies.
6	Allam, Zaheer and Jones, David. 2018. “Promoting resilience, liveability and sustainability through landscape architectural design: A conceptual framework for Port Louis, Mauritius; a Small Island Developing State.” International Federation of Landscape Architects World Congress.	Conference Paper	Published	It was found that there is a need to showcase urban areas as ecosystems. Mauritius, being a SIDS, has a fragile ecosystem. The role of ‘green and blue infrastructure’ was highlighted as a potential solution to promote resilience in the wake of climate change. Moreover, the role of governance was highlighted as a key dimension for the smooth implementation of proposed sustainable policies.
7	Allam, Zaheer. 2017. “Building a Conceptual Framework for Smarting an existing city in Mauritius: The case of Port Louis.” Journal of Biourbanism (4-1&2): 105-123.	Journal Article	Published	In the application of a Smart City infrastructure to an existing City like Port Louis, one needs to cater for three dimensions: (1) the human dimension, (2) planning and management, and (3) the right infrastructure. Those support the Smart City Framework being proposed by the author. Moreover, for the implementation of the proposed framework, the SMART model can be applied as it caters for micro, meso and macro levels within the city.
8	Allam, Zaheer and Newman, Peter. 2018. “Economically incentivising Smart Urban Regeneration. The case of Port Louis, Mauritius.” Smart Cities (1): 53-74.	Journal Article	Published	This study builds from previous findings and proposes a Smart Urban Regeneration Framework to successfully apply Smart City infrastructures in existing cities. An Urban Regeneration Scheme is proposed for the City of Port Louis applicable to an Action Plan Zone. The implementation of the proposed scheme will lead to positive economic growth and enhanced liveability

Table 3. Status and findings of publications

CHAPTER 5 – RESULTS AND DISCUSSIONS

This thesis proposes a new Smart City framework (Figure 5) where the most conspicuous aspect is to use the Smart City paradigm as an enabler for sustainable development to meet the goals of SDG 11. This approach offers a contrasting viewpoint towards Smart Cities and diverges from the ongoing branding wars displayed by Smart City service providers and from the greenfield modernist smart city developments hailed in literature. Paper 1 and 7 showcases that ICT can act as an enabler rather than requiring its own dimension, as they do not automatically lead to the right urban outcomes. Instead ICT needs to be calibrated to support local needs and one must avoid the standardised planning processes that can lead to out-of-context solutions. The smart infrastructure applies to the three fundamental dimensions of the urban fabric and showcases how smart culture, smart metabolism, and smart governance can be achieved.

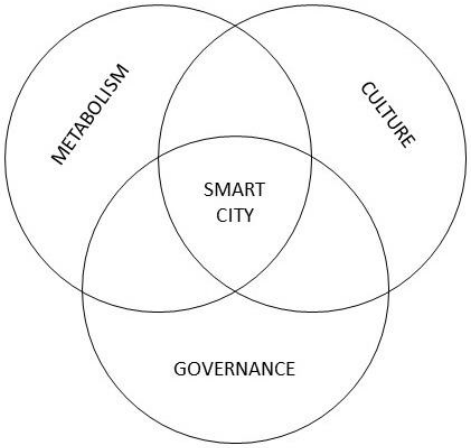

Figure 5. The Smart City framework (Allam and Newman, 2018b)

Through the dimensions of Culture, Metabolism and Governance, the proposed model encourages the use of ICT to further support the liveability factor through the urban Smart City policy, thus ensuring a localised and contextual planning response to Smart Cities. Moreover, the proposed Smart City paradigm is focused on the application to cities while achieving the goals of SDG 11. The three dimensions together further avoid the seclusion of Smart Cities with their surroundings like the current Mauritian trend of building isolated Smart City Modernist New Towns, which can cause conflicts with neighbouring fabrics as shown in Paper 3. Each of the three proposed dimensions can be seen to coincide in their aim to help create a better concept of a Smart City.

To further ensure the integration of society (liveability levels) of Smart Cities, it is noted that the metabolism of cities need to be catered for. Paper 4, 5, and 6 explore these questions and reveal issues and solutions regarding waste management and resilience to climate change. Since Port Louis is a historical Port City hosting structures of high cultural importance, Paper 2 and 3 showcases the importance of culture to increase liveability and how those can be celebrated and made to play an integral role in urban regeneration.

As opposed to other Smart City Frameworks that place a primary emphasis on technology in isolation, the proposed Smart City Framework (Figure 5) supports liveability and sustainability and is therefore likely to fulfil the SDG 11. This rationalises the implementation of the proposed framework by cities. Paper 1 further showcases how the economy of cities can be positively influenced by Smart Cities, and Paper 3 presents findings from a focus group on emerging themes that need to be considered for regenerating the Economy of Port Louis. Building from this, a Smart Urban Regeneration Framework is proposed (Figure 6) in paper 8.

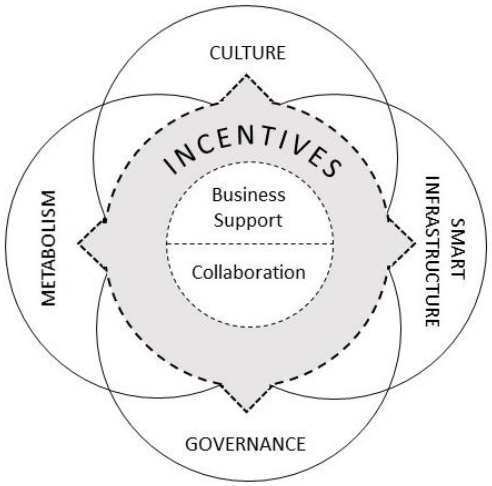

Figure 6. The Smart Urban Regeneration Framework (Allam and Newman, 2018a)

Paper 3 revealed that the private sector favoured fiscal incentives, as composed in Special Economic Zones, to encourage investment. However, to ensure that urban regeneration does not occur solely driven by an economic drive, the proposed Smart Urban Regeneration Framework (paper 8) supports the three key dimensions of the Smart City Framework (paper 1). Together with the findings from the various papers, an 'Urban Regeneration Scheme' for the City of Port Louis is further proposed (Paper 8). The specific recommendations (Paper 3 & 6)

identifying contradicting policies in local guidelines were taken into consideration for providing a contextualised Smart City solution for Port Louis.

An econometric forecasting of the Urban Regeneration Scheme for the city of Port Louis (paper 8) showed positive results: USD 1.2 Billion in private investment, USD 182 Million as public revenue, and 94,588 as jobs creation over a 6-year period.

An extended portion of this chapter is featured through Paper 1 and Paper 8.

CHAPTER 6 – CONCLUSIONS

The Conclusions of the Thesis are made by showing how each of the research questions have been answered.

1. How can Smart City be redefined from a branding competition to enable a more inclusive, safe, resilient and sustainable city?

The world is witnessing a mass exodus of people from rural areas to urban areas with more people now living in cities and this trend is being predicted to be constantly on the rise for decades to come. This rapid demographic boom is coupled with a mass adoption of modernist principles that are disruptive to cultural fabrics that contribute much to both identity and sense of belonging. The sustainable development of cities has been proposed by the United Nations and by scholars to cope with this rapid growth agenda where many people are easily left behind, and the environmental implications and cultural attributes are often left out of the economic equation. Nonetheless, each city and state face its own set of inherent domestic issues and potential markets needed to create 'inclusive, safe, resilient and sustainable' future cities. Smart Cities has been proposed in recent times to help manage this complex and difficult transition to the future. It promises much as the digital technologies have driven much of the recent economy. However, that does not mean that by branding a city Smart and giving a lot of money to big ICT companies, that there will be a trickle down to enable the UN agenda to be achieved. Models of governance need to support the Smart City agenda so as to provide a better integration of Smart City technologies while enhancing the liveability of urban fabrics. The thesis has been constructed around how the Smart City paradigm needs to be embraced but given specific strategies that can enable the broader social, environmental and economic agenda of the UN to be achieved. This involved creating a Smart Cities Framework.

This thesis has shown that the literature on Smart Cities could be used to set up what a Smart Cities Framework could be and concluded that it needed to integrate Culture, Metabolism and Governance. Aligning the Smart City paradigm with the goals of the SDG 11, was created through the Smart City Framework. This was outlined in Papers 1, 3, 7 and 8. These papers have been accepted and published as helping to define a new direction for the Smart City. It then showed how the Framework could be applied to Port Louis as a case study.

1.1. How can this be applied to Port Louis, Mauritius, as a model Smart City in the emerging world?

The theoretical application of existing Smart City Models showcased that ICT infrastructures must support human, social and economic dimensions, and the Smart City Framework as outlined in this thesis proposes to do this through three key dimensions: Culture, Governance and Metabolism. A focus group approach validated the proposed three key dimensions and further underlined two additional components to consider while studying how Smart City infrastructures can be applied specifically to existing cities. A Smart Urban Regeneration Framework was proposed to help with the delivery of ICT-based solutions within the Culture, Metabolism and Governance arenas. This model was highlighted as a better localised and contextual response to adopting Smart City Technologies to existing cities, and thus better responds to the requirements of the SDG 11. Papers reflecting on the application of the smart city paradigm to emerging cities, exemplified by Port Louis, have been discussed in paper 7. It is seen that three dimensions need to act as pillars for any Smart City framework. These are the human dimension, planning and management, within the right infrastructural environment. However, implementation needs to cater for micro, meso and macro levels which takes into consideration the inherent properties of each city.

Each of the other papers has taken the core ideas and applied them to Mauritius and some of the details are outlined below in the different components of the Smart City Framework.

2. How can urban regeneration be achieved through the application of a Smart City Framework in an existing city?

Only by using ICT applied to Culture, Metabolism and Governance could cities begin to apply Smart Cities to the old parts of their urban fabric rather than greenfields with a heavy modernist style of architecture and planning. Such an approach can lead to urban regeneration achieving the hallmark features of SDG 11. This thesis established that currently the Smart City paradigms do not cater for SDG 11 which aims at making cities inclusive, safe, resilient and sustainable. To address this gap in knowledge papers 2, 4, 5 and 6 have been written and published. The main findings highlighted the essential role that Culture, Governance and Metabolism have to play in achieving SDG11 through a novel Smart City framework and that there is no obvious reason why

urban regeneration cannot be a focus for the new ICT approaches. It is mostly a matter of perceptions that ICT needs to be branded as a modernist, greenfields urban tool.

2.1 How can culture be an effective driver to encourage an inclusive, safe, resilient and sustainable city?

The role of culture has been highlighted in paper 2 and it is seen that this aspect of cities has been overlooked by the modernist approach of the existing Smart Cities paradigm. Nonetheless, this thesis showed that Culture can be a major pillar and driver of sustainability. Besides being a 'green' industry with minimal contribution to GHG emissions, Culture empowers the local population while promoting social inclusiveness, substantial economic growth and liveability.

2.2 How can the metabolism of cities be improved to encourage an inclusive, safe, resilient and sustainable city?

Throughout the unfolding of this thesis, it became apparent that understanding Metabolism is an essential dimension that leads to sustainability. This approach is underdeveloped in existing modernist Smart Cities paradigms. To this end, paper 4 applied Newman's Extended Metabolism Model to the city of Port Louis in a bid to assess the city's Metabolism. Four key sectors which involved consequential materials flow were identified that affect the Metabolism (and liveability) of the city: the energy sector, water industry, waste management and transportation dimensions of the city. The findings of this study showed that metabolism is intricately linked to enhanced liveability. Promoting an understanding of materials flow within cities and proposing novel approaches that merge the hallmark dimensions of the proposed Smart Cities paradigm will offer a better understanding of how a city's performance affects its sustainability and liveability. If conditions can be optimised for better Metabolism whilst improving liveability, then this will be a major driver of sustainability as well as the other elements of SDG 11.

2.3 How can the governance of cities be improved to encourage an inclusive, safe, resilient and sustainable city?

To further the understanding of pathways available for bridging the gap between the proposed Smart City paradigm and the SDG 11 goals, paper 5 and 6 have been developed. These papers highlighted the major flaw in the 'one size fits all' approach so vehemently being postulated by existing modernist Smart City paradigms. Instead, the findings of these studies lay the onus on the need for better Governance, for enhanced management protocols within the right dimensions of accountability and responsibility. Governance goes beyond the institutionalisation of the city. It is viewed as the connecting nerve that connects every aspect of the new smart city paradigm with the need for inclusive, safe, resilient and sustainable cities. The two papers made the case that a robust governing institution equipped with a coherent and effective set of policies can better monitor the metabolism of cities and can help in developing a conducive environment for the deployment and celebration of culture across cities; both being essential cogs in the machinery towards the SDG 11.

3 How can the application of a Smart City Framework in an existing city help in social and economic regeneration?

As a case study, the culturally-rich capital city of Mauritius, Port Louis, has been chosen as it highlights an unfair business environment largely fuelled by the competition between existing cities and new mushrooming Smart Cities in greenfields. An 'Urban Regeneration Scheme' (URS) was generated for Port Louis which offers guidelines on fiscal measures that can be adopted to pave the way towards socio-economic regeneration. An econometric forecasting approach predicted positive gains in terms of employment, business opportunities and investment.

Whilst such matters can only be judged after they have been delivered and evaluated, it would seem that the authorities responsible are now making plans along the lines outlined in the papers in this Thesis. The Government of Mauritius adopted the recommendations of this thesis to implement an Urban Regeneration Scheme to help economically regenerate existing cities to match developments from emerging Smart Cities. This has been expanded at national level and implemented through the National Budget of 2018-2019.

The findings of this thesis highlight that the Smart City paradigm can indeed be redefined by focusing on Culture, Metabolism and Governance. The proposed frameworks reveal pathways to respond to sustainability while regenerating old cultural fabrics of cities. This is done through an enhanced governing model while encouraging private investment. This model is thus replicable to other developing countries that often lack the public financial capabilities for urban regeneration. By facilitating the adoption of policies in these areas, through the implementation of the right contextualised strategies, this thesis suggests a pathway to urban sustainability as proposed by SDG 11.

6.1 RECOMMENDATIONS FOR FURTHER RESEARCH

Each city has its own intrinsic and extrinsic factors that affect the delicate balance between socio-economic development and sustainability. There is need for each city to weigh the Smart City paradigm that has swept the urban world in recent years, to see if it is able to fulfil the bigger goals of SDG 11. Smart Cities branding should not be adopted unless it is seen to assist with the big issues of equity and inclusion, of safety and security in homes and streets, of climate change and all the other issues of the SDG's, as well as the resilience and adaptation to major events that can undermine the future of the city. Such matters can be brought into a bigger framework of consideration by using the Smart Cities Framework. Thus, the first recommendation for further work is that a lot more cities need to try and apply the Smart Cities Framework to their cities. These can then be gathered into a much bigger collection of case studies to review the utility and benefits of the Smart Cities Framework.

There is also more detailed work to be done in Mauritius that could be a useful model for other cities. Three other research/policy proposals are suggested.

First, there is a need to broaden the community engagement in this issue. The economic dimension of cities is what provide governing bodies with financial resources to manage the city sustainably. In this study, there has been an identification of key dimensions that need consideration in an Urban Regeneration Scheme. This exercise adopted a focus group approach involving selected key stakeholders from private and public institutions. While the input was necessary to gear economic regeneration, future studies must be extended to include the viewpoint of urban dwellers and others that form the major strata of the city in order to gain better quality data on what the city really wants and needs. To encourage a more inclusive and elaborate understanding, it is suggested a more detailed survey is undergone that strengthens the representation of the community at large.

Second, the process of change within institutions needs to be monitored and assisted. Proposing a change at urban scale will entail major disruption of established policies, regulations and guidelines. Resistance to change will be expected. To ensure a smoother transition towards sustainability, guidelines for change implementation must be sought. This can be in the form of a roadmap backed by a theoretical foundation that caters for all levels of the city. The Socio-Technical transition theory as proposed by Geels and Schot (2007) can be useful in that matter.

Moreover, embarking into such an endeavour at city level involves a considerable financial input. Such consideration needs to be understood and justified in budgetary proposals and new partnerships, sensible to both economy and society, must be sought.

Third, a Smart City Strategic Plan needs to be developed based around delivery mechanisms. The Smart City Framework was pursued in Mauritius by creating a number of implementation and delivery mechanisms such as the Urban Regeneration Framework. This helped to shape ICT applications by providing a basic guide on how to achieve a sustainable implementation and outcome. However, other mechanisms are likely to be needed for all the specific issues identified. Those need to be calibrated to address the specific challenges each part of the city faces. Once these are created a Smart City Strategic Plan could be drawn together that shows how the SCF leads to delivery mechanisms; these could be completed by suggesting a range of Key Performance Indicators and timelines. Detailed monitoring and reporting of the different areas of the Smart Cities Strategic Plan can then be done.

Similar approaches could be done by other cities and such Smart City Strategic Plans can then be shared at international meetings. Research pulling all these demonstrations into a coherent assessment could then be conducted.

The dynamics of urbanisation in this globalised era is constantly evolving with new dimensions being unveiled such as immigration issues, geopolitical situations and trade agreements as well as the constantly unfolding issues of climate change. Building from this study, new sets of questions arise such as the two following can help in building a more inclusive and resilient model: (1) How can the new Smart City Framework protect cities against the ailments of climate change? And, (2) How can the Smart City Framework cater for emerging issues such as changing migration patterns, geopolitical issues like wars and trade agreements? These issues may be too big for the Smart City Framework to manage though ICT has increasingly been adopted for many new issues and it may be the kind of thing that cities can use for managing their futures.

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APPENDIX

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Redefining the Smart City: Culture, Metabolism and Governance

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Abstract: The Smart City concept is still evolving and can be viewed as a branding exercise by big corporations, which is why the concept is not being used by the United Nations (U.N.). Smart Cities tend to represent the information, communication, and technological (ICT) industry alone without considering the values and cultural and historical profiles that some cities hold as legacies. However, the technology inherent in Smart Cities promises efficiencies and options that could allow cities to be more "inclusive, safe, resilient, and sustainable" as required by the U.N. agenda including cultural heritage. There is a notable lack of Smart City application to cultural and historical urban fabrics. Instead, the modernist new town approach has emerged under this new rubric leading to many problems such as urban decay and unsustainable car dependence. This study therefore presents a review of the literature on the nature, challenges, and opportunities of Smart Cities. A new Smart Cities framework is proposed based on the dimensions of culture, metabolism, and governance. These findings seek to inform policy makers of an alternative viewpoint on the Smart City paradigm, which focuses on urban outcomes rather than technology in isolation.

Keywords: smart cities; culture; metabolism; governance

1. Introduction

A multitude of contrasting views on Smart Cities have emerged since their proposal. Some researchers visualise the Smart City approach as a potential solution to the issues pertaining to enhanced urbanisation and the need for sustainability [1–3]. Other studies claim that Smart Cities may lead to a dystopian world regulated by technocratic governments that propel citizens to subaltern roles [4,5]. Some authors highlight the unsustainability of this novel urban concept [6]. However, despite the differing viewpoints, the concept of Smart Cities is gaining momentum around the world as shown in Figures 1 and 2, though Figure 1 suggests this may have peaked in 2015.

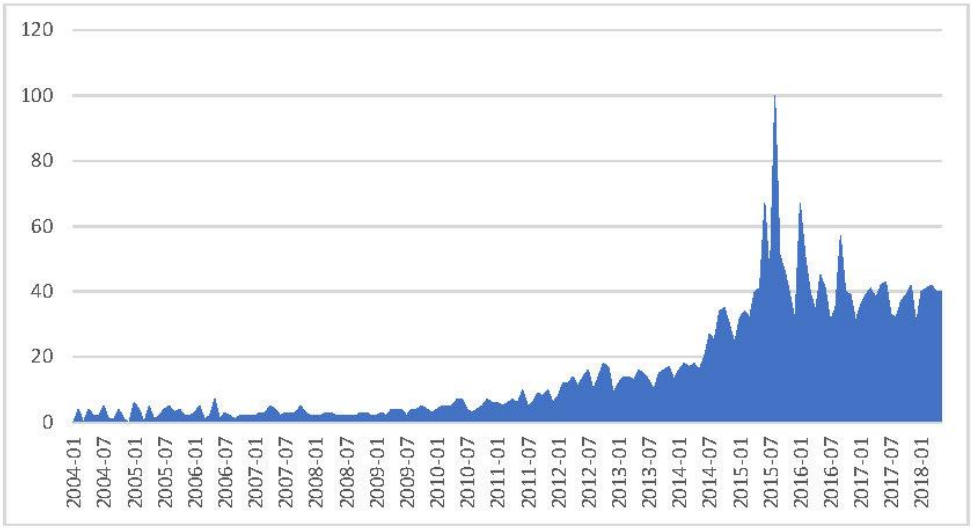

Figure 1. Relative number of hits for Smart Cities searches in Google between 2004 and 2018 [7].

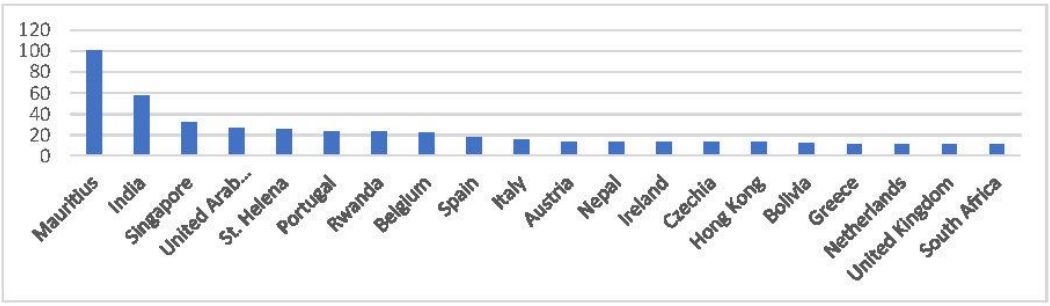

Figure 2. Countries with most searches for Smart Cities between 2004 and 2018 (Source: Google Trends Explore).

The popularity of Smart Cities projects and programs has increased across the globe, such as in India, China, U.A.E., South Korea, and even in Small Island Developing States like Mauritius [8–12]. Data from 2004 to 2018 were sourced from Google Trends [7] and the *y*-axes on both Figures 1 and 2 highlight the popularity (ranging from 0 to 100). A study of the term "Smart Cities" highlights that Smart Cities were most popular in Mauritius (Figure 2) and a case study on these smart cities is presented below.

The Smart City paradigm is associated with the Internet of Things, sensors, and big data, leading to informed and data-led governance [10,13]. Despite the rather permanent association of Smart Cities with big data computation [14,15], the notion of this paradigm is not new. Shelton et al. [16] argued that, from a historical perspective, the idea of Smart Cities, in the form of a scientific approach to study and manage the cities, is a century-old concept sought after by planners and engineers. From a big data computational perspective, Light (2005) highlighted the role of computer models in solving urbanization-related issues dating back to the post-World War 2 era, but LeGates, et al. [17] demonstrated the relative unpopularity and debatable success, if any, of such approaches.

Smart Cities are often painted as the "magic bullet" to all urbanisation issues by proponents [16,18,19]. Notably, most of the proponents of the Smart City paradigm in this digital era refer to newly built Smart Cities such as Masdar City in Abu Dhabi, Songdo and Hwaseong Dongtan in South Korea, and PlanIT Valley in Portugal [20,21]. However, these initiatives were designed in isolation and tend to operate

in silos, having a negative effect on other surrounding cities in the form of business loss and cultural erosion [21,22]. Moreover, the viability of erecting new Smart Cities is being questioned due to their restricted affordability and inability to attract inhabitants.

Before continuing this analysis on the future of the Smart Cities concept in response to these criticisms, the United Nations (U.N.) has been very guarded. The global debate about future cities has many dimensions and contributors and much has been written about the importance of the U.N. Sustainable Development Goals (SDG) for 2015–2030, which now includes an urban goal: "inclusive, safe, resilient, and sustainable cities". The urban SDG has 10 targets and 14 indicators, but throughout all these instructions for cities, none say that we should have Smart Cities, despite the increasing use of the term. The reason for this omission is apparently that Smart Cities are seen to be essentially a branding war between different multinational corporations in the information, communication, and technological (ICT) space. The solution, as set out in this paper, is for cities to adopt the SDG goal, targets, and indicators and determine how to integrate the technological opportunities that are emerging as the Smart City. Perhaps the Smart City can be revised into being more than a corporate branding war.

Some literature is pushing in this direction. Studies have highlighted the potential application of smart technologies to existing cities rather than building new cities just for an ICT branding opportunity [16]. Others have called for the use of smart infrastructures and policies with better public-private partnerships and citizen participation aiming at a more sustainable and livable city [16,23–26]. Thus, the literature is suggesting that the Smart City concept requires further investigation and values directing the outcomes of smart technologies. This is the basis of our paper; we attempt to provide some substance and direction to the concept of Smart Cities, so they are less focused on smart technologies for its own sake and more about solving the core problems in cities and their regions. Our research suggests that there are three primary issues that need attention in cities with which smart technologies should be able to assist in solving: (1) culture, in terms of how cities can build on their urban history and create the meanings behind why people and place are associated in the city; (2) metabolism, which is how the excessive resource consumption and waste production of cities can be significantly reduced; and (3) governance, which involves how can cities create new partnerships between local and regional governments, business, and community to enable urban solutions to be delivered.

As such, this study seeks to review the literature about the Smart City paradigm in terms of culture, metabolism, and governance. These findings are then used to propose a theoretical framework for the Smart City paradigm. The proposed paradigm includes a citizen-centered outcome-oriented approach rather than a technology-based, corporate-centered solution. The findings of this study add to existing knowledge about the Smart City paradigm. We further expect that this study may act as a guide for policy makers from emerging cities who aspire to leapfrog into the 21st century without the need to invest heavily in ICT, but want to work more on human capital and governance building for ICT where necessary, but not viewing ICT as a necessary and over-riding project for development.

2. Smart Cities as a Brand

It is interesting to study the perceived popularity of Smart Cities in contrast to its less popular counterparts like Sustainable Cities, and Resilient Cities. The term "Sustainable Cities" emerged with the need for cities to address sustainable development [27], whereas "Resilient Cities" emerged by planners and designers questioning how to quickly and efficiently recover from urban perturbations, often linked with climate change [28]. A comparative analysis (Figure 3) of the terms Smart Cities, Sustainable Cities, and Resilient Cities [29], shows that Sustainable Cities was more popular until late 2010. Following this, the term Smart Cities emerged as most popular though it peaked in 2015. In August 2015, the term Resilient Cities was factored at 3% and Sustainable Cities at 5% in comparison to the popularity of Smart Cities, which was at its highest point. This trend inspired questions as to how and why Smart Cities increased in popularity compared to its counterparts.

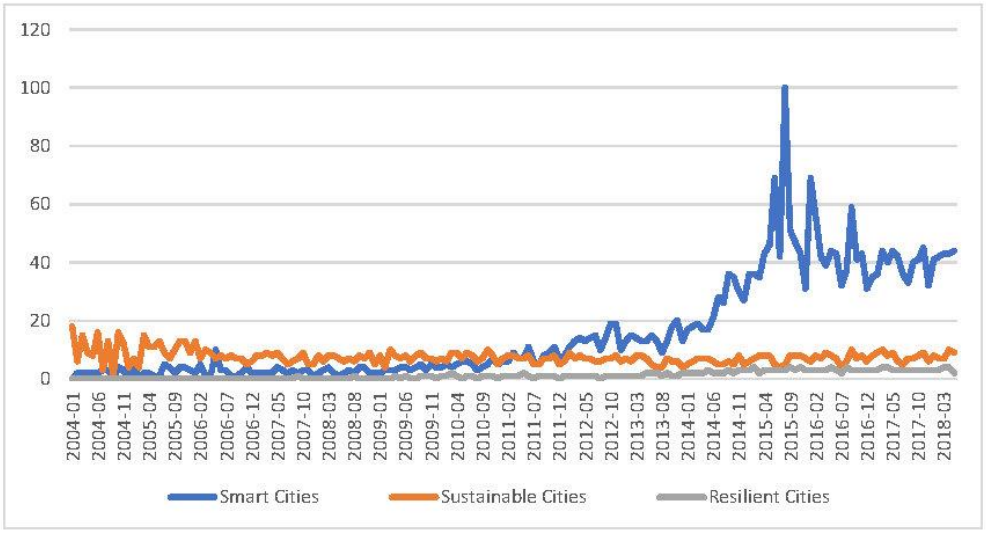

Figure 3. Number of searches for three types of cities worldwide [29].

The Smart City approach to solving urbanisation issues is not a standalone concept, being backed and supported by corporations with substantial financial resources [30,31]. A highly competitive market exists where companies compete to tap into this profitable market. In a previous analysis [32], the two main leaders are Cisco and Siemens, which were closely followed by a set of contenders including IBM, Hitachi, Microsoft, GE, Schneider Electric, and Bosch, among others (Figure 4) [32]. Sadowski [33] warned about the potential agenda of Smart City corporations in supporting a stand-alone profit-making agenda through the implementation of Smart City solutions. These commentators suggest that if cities invest in these corporations as part of their branding exercise rather than investing based on the values and visions derived from participatory approaches to governance, as outlined by Nam and Pardo [10], then smart technology may simply be a wasted investment.

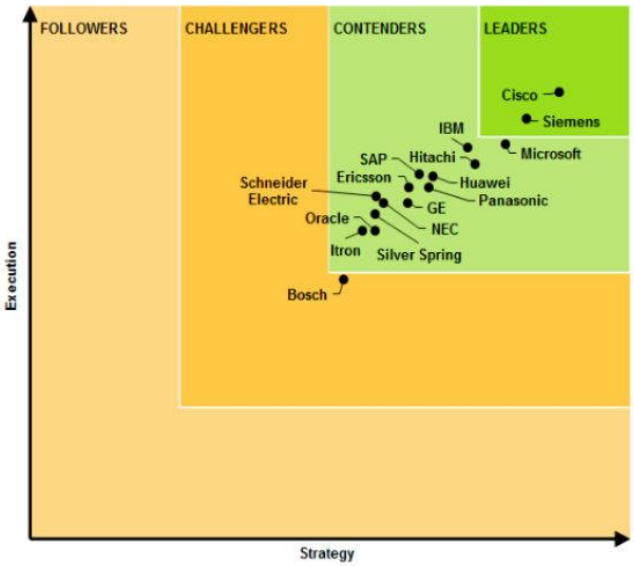

Figure 4. Corporate leaders in Smart City solution suppliers [32].

Hollands [34] reflected on the relative popularity of the term Smart City and questioned the labelling process. The author pointed out that although the application of ICT tools are a prominent facet of a Smart City, a hidden agenda appears to be intricately linked to e-governance and a promotion of "informational business interests". Later, the same author warned about the growing popularity of corporate-led Smart Cities where the prime focus is on profit alone, with little room for ordinary people to participate in the smart development and governance of the city [35]. This view has been shared by Kitchin [12] who highlighted the lack of collaboration and engagement from various stakeholders in contributing to the city in a Smart City approach. These authors are identifying how the Smart City paradigm is being viewed and proposed by corporates as a one size fits all approach, which has been the basis of a long tradition of technology policy and critique [36,37]. Such technology is feared because it begins to control us rather than us controlling it. With Smart Cities, there is legitimate fear that such a paradigm may devolve into mass biometric surveillance and a form of data-led manipulation [30]. This is easily linked to the concept of "big brother" as prophesied by Orwell [38]. It is therefore suggested there is a need for more participatory and citizen-centered revamping of cities through the Smart City paradigm [35]. So, what is a Smart City and what could it become?

3. Defining Smart Cities

Smart Cities as a term is well used in popular and academic literature, but a proper definition is still lacking [39,40]. Table 1 sets out six definitions based mostly on the reviews completed by Chourabi et al. [40] and Cocchia [41]. Often, the definitions only explain the characteristics of a "good" city, whereas others emphasize technology.

Table 1. Proposed definitions of smart city adapted from Chourabi et al. [40] and Cocchia [41].

Author(s)	Definition
Giffinger, et al. [42]	"A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens."
Hollands [34]	"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens."
Harrison, Eckman, Hamilton, Hartswick, Kalagnanam, Paraszczak and Williams [13]	A city "connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city"
Natural Resources Defense Council [43]	"A city striving to make itself "smarter" (more efficient, sustainable, equitable, and livable)"
Toppeta [14]	A city "combining ICT and Web 2.0 technology with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, in order to improve sustainability and livability."
Washburn, Sindhu, Balaouras, Dines, Hayes and Nelson [21]	"The use of Smart Computing technologies to make the critical infrastructure components and services of a city—which include city administration, education, healthcare, public safety, real estate, transportation, and utilities—more intelligent, interconnected, and efficient"

Table 1. *Cont.*

Author(s)	Definition
Setis-Eu (Cited in Cocchia [41])	"Smart City is a city in which it can combine technologies as diverse as water recycling, advanced energy grids, and mobile communications in order to reduce environmental impact and to offer its citizens better lives"
Dameri [44]	"A Smart City is a well-defined geographical area, in which high technologies such as ICT, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development"
Northstream [15]	"Concept of a Smart City where citizens, objects, utilities, etc., connect in a seamless manner using ubiquitous technologies, so as to significantly enhance the living experience in 21st century urban environments"
Hall, et al. [45]	"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens"
Su, et al. [46]	"Smart City is the product of Digital City combined with the Internet of Things"
IBM [47]	"Smart City is defined by IBM as the use of information and communication technology to sense, analyze and integrate the key information of core systems in running cities"
California institute (2001 cited in Cocchia, (2014 #287))	"A smart community is a community that has made a conscious effort to use information technology to transform life and work within its region in significant and fundamental rather than incremental ways"

4. Review of Smart City Frameworks

Despite an absence of consensus for a universal Smart City definition, several authors highlight key dimensions for establishing a Smart City framework (Table 2). However, just as with the definition, desired key dimensions for a Smart City vary considerably. Key indicators, such as smart governance, smart people, and smart infrastructure, are popular in the proposed frameworks but pillars of smart education and public safety seem to be less present (Washburn, Sindhu, Balaouras, Dines, Hayes and Nelson [21] and Neirotti, et al. [48]). Notably, the concept of smart living can be interpreted as a coupling with livability, where the key dimensions of livability include public safety, education, and access to proper healthcare [49]. Hence, despite not being apparent in some of the frameworks as standalone pillars, these dimensions have been integrated into technological approaches by a few commentators. Nonetheless, despite the fact that UNESCO acknowledges the central role that culture plays in city regeneration [50], only the study of Neirotti, De Marco, Cagliano, Mangano and Scorrano [48] assigns the concept of culture a prominent place in the Smart City framework. As can been seen from Table 2, the Smart City frameworks include several overlapping and non-overlapping themes, which underlines the lack of a universal framework or consensus as to the required dimensions for Smart Cities.

Table 2. Key dimensions in Smart City frameworks.

Indicator	Petrolo, et al. [51]	Nam and Pardo [10]	Chourabi, Nam, Walker, Gil-Garcia, Mellouli, Nahon, Pardo and Scholl [40]	Washburn, Sindhu, Balaouras, Dines, Hayes and Nelson [21]	Dameri [44]	Neirotti, De Marco, Cagliano, Mangano and Scorrano [48]	Balakrishna [52]	Mosannenzadeh and Vettorato [53]
Smart Governance	X	X	X	X	X	X	X	X
Smart People	X	X	X		X	X	X	X
Smart Economy	X		X			X	X	X
Smart Living/Livability	X			X	X	X	X	
Smart Environment	X		X		X	X	X	X
Smart Mobility	X			X		X	X	X
Smart Infrastructure	X	X	X	X		X	X	X
Smart Education				X		X		
Smart Healthcare				X		X		
Public safety				X		X		
Culture						X		

The most common terms used in the frameworks are Smart Governance, Smart People, and Smart Infrastructure, with most assuming that these concepts lead to better economic outcomes. These terms will be outlined to explain some of the key ideas that help frame Smart Cities.

No common consensus exists as to how Smart Governance should be defined in Smart Cities despite many countries having Smart Cities ProgramsMeijer and Bolívar [54]. Rather than just allowing as much ICT investment as possible, commentators have suggested ICT can be directed into creating a much more inclusive governance system. Paskaleva [24] highlighted the salient feature of Smart Governance as be the ability to promote a collaborative digital milieu based on promoting business competitiveness in a conducive environment of partnership and collaboration through digitally established knowledge networks. Others have shown how Smart Governance could be the key to enabling citizen engagement in a Smart City to ensure decision-making and implementation activities are transparent and explained clearly [10,24]. Moreover, Kitchin [12] highlighted how Smart Governance could become the central role of policy development based on rigorous data analysis, which forms the core of technocratic decision-making, designed to empower its citizens within a transparent framework.

Smart People is also a popular concept with commentators who suggest that smart technologies can help integrate the social and human capital within a city. Such aspects cater to a pronounced drive for life-long education and a collaborative role in social life within a creative and adaptable setup [55]. The Smart People concept merges with governance through the participative role of citizens in the urban milieu within a smart but transparent decision-making process [12]. Neirotti, De Marco, Cagliano, Mangano and Scorrano [48] further demonstrated the need to address the human capital in the Smart City not only as end-users but as actual contributors to the process of change.

Smart Infrastructure goes beyond ICT for its own sake, suggesting that infrastructure is needed to solve the problems faced by urbanisation, which must now use ICT to become more efficient and sustainable [56]. Balakrishna [52] analysed the potential of smart mobile devices in terms of built-in sensors and proposed three key indicators of Smart Infrastructure: (1) real world awareness through real-time big data capture and analysis, (2) knowledge engineering that translates big data into exploitable knowledge, and (3) interconnectivity that proposes a network of data-driven knowledge sharing across all domains of the city. This could join with the concept of urban metabolism that proposes a rigorous control of inputs within cities to achieve more rapid sustainability outcomes [49,57].

The literature in these three main dimensions invariably fails to bridge the gap between existing and new cities. The whole impetus of the Smart City is toward establishing new cities rather than existing ones with existing infrastructure and often rich and different urban fabric. This process is in the tradition of modernist town planning since the 1930's, which aimed to create a singular, modern urban fabric either replacing old cities or creating new towns and suburbs [16]. This geographical tension between building new smart cities or regenerating existing cities through application of smart solutions requires further analysis [16].

5. Dichotomy between Bringing Smart Technology to Old Cities or Building New Cities: A Case Study from Mauritius Smart Cities

Smart Cities are usually created in new locations on the outskirts of present cities in the modernist tradition of New Towns. The emergence of new cities in close locality to existing cities poses the risk of encouraging urban sprawl and the resulting automobile dependence, fossil fuel consumption, and unhealthy lifestyle [57–59]. Literature is scarce about how to apply smart technology to existing cities and the literature seems to uniquely favor the emergence of new cities through a series of off-the-shelf plug and play solutions offered by specialised information technology (IT) companies as elaborated above.

Mauritius, for example, has established several Smart Cities on the outer edge of its historic capital city, Port Louis. Figure 5 showcases the planned Smart Cities in a 10 km radius from the Central

Business District of Port Louis. Out of the nine planned Smart Cities, five have gained approval from government and are being built, while four are under evaluation.

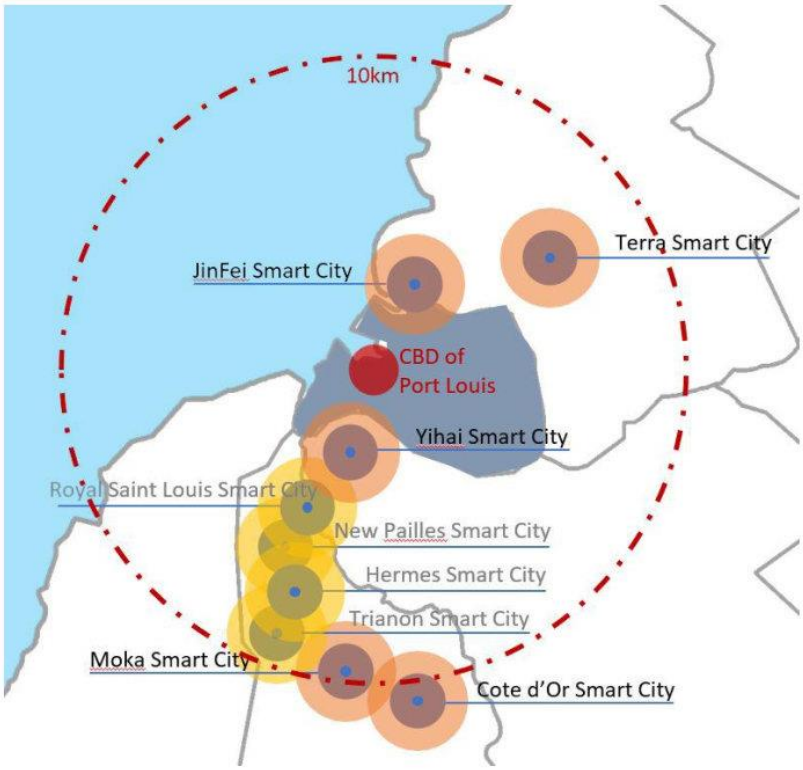

Figure 5. Planned Smart Cities in a 10 km radius from the Central Business District (CBD) of Port Louis, Mauritius.

Figures 6–9 show the modernist architectural language adopted by Smart Cities to support a heavy branding by competing companies.

Figure 6. Cote d'Or Smart City, Highlands, Mauritius [60].

Figure 7. Jin Fei Smart City, Baie du Tombeau, Mauritius [61].

Figure 8. Yihai Smart City, Pailles, Mauritius [62].

Figure 9. Moka Smart City, Moka, Mauritius [63].

These new Smart City towns are part of the long history of New Towns created as part of the modernist tradition [64]. This tradition, with its roots in Le Corbusier's Congrès Internationaux d'Architecture Moderne (CIAM) movement, aimed to start from a clean slate and use modern high rise and freeway architecture to create a new kind of urban experience. The problems that developed from this included automobile dependence and urban decay in the old cities where development declined [16,65,66]. Many cities have been moving away from the modernist urban paradigm, but the Smart City movement is at least in part trying to revive it. This may also be because the emphasis on ICT alone provides a vacuum in planning and policy values, enabling any agenda to be set, as long as it is "smart". This paper suggests that Smart Cities will fail to deliver better cities unless clearly driven by an agenda that can explain the definition of a "better" city.

Portions of the Smart City paradigm are realising that new technology needs to not only set an agenda as outlined here, but must be able to recognise, respect, and regenerate the various parts of the urban fabric. India, for instance, has pledged to build 100 Smart Cities based on four different strategies: (1) retrofitting existing facilities to achieve Smart City objectives, (2) redevelopment of existing areas by replacing amenities better aligned within a Smart City framework, (3) greenfield development aiming at building new smart areas in vacant areas, and (4) pan-city development that proposes technology applications to existing city networks [67]. However, according to Bosch [68], the 100 Smart Cities mission is flawed as it focuses on business opportunities by international Smart City developers, such as IBM, that want to create a market estimated to be worth $1.56 trillion by 2020 [68]. Bosch warns against this trend in Indian urban realities and instead suggests a focus on cultural awareness of the urban fabric that exists and the potential mushrooming of "smart enclaves" within cities [68].

This same approach was proposed by Shelton et al. [18] who postulated that focusing on the application of a Smart City paradigm in more mature cities rather than building new cities will be more productive. These authors discussed the nature of big data-driven governance that should be analyzed within the historical and spatial boundaries of the actual city. This approach caters to people rather than forcing the people to cater to the Smart City vision. However, this focus would still require new kinds of governance [69].

Although building from a fresh start is perhaps easier, though usually t around three times more expensive than regenerating old areas [57,59], Smart City technology can be adapted to existing cities. This will need to be tailored to address contextual and governance challenges, but all issues in urban regeneration lend themselves to being more easily solved by using Smart City technology [15,70]. To create more appreciation and accountability in the Smart City paradigm, a simpler framework is proposed that can be applied to new and more mature cities and indeed all forms of urban fabric to show how a Smart City can achieve more of the broader goal specified in the U.N. SDG of creating "inclusive, safe, resilient and sustainable" cities.

6. Creating a Smart City Framework

The most conspicuous aspect of the proposed Smart City framework set out in Figure 10 is the absence of smart ICT-based infrastructure as its own dimension. This has been shown throughout the paper as a major problem and its lack of a values base has undermined the economy of many cities, as this has led to isolated Smart City modernist New Towns. The model being proposed in Figure 10 has the values base firmly set in the three driving forces: culture, metabolism, and governance. These values provide a focus for the Smart City to address the issues of urbanization [16,18,19] and to welcome urbanization as an essential condition for growth [71]. These values also allow policy-makers to distinguish between different types of cities and different urban fabrics and to highlight the need for different developmental agendas [57,64]. This approach is far from the "one-size fits all, modernist model presented by Smart City suppliers, suggesting that smart infrastructure, as an isolated item, places an additional financial burden on the city's governing bodies despite most cities struggling to find finance for their multiple socio-economic problems [65]. Instead, this approach applies smart

infrastructure to each of the three fundamental values of a city in order to show how smart culture, smart metabolism, and smart governance can be created.

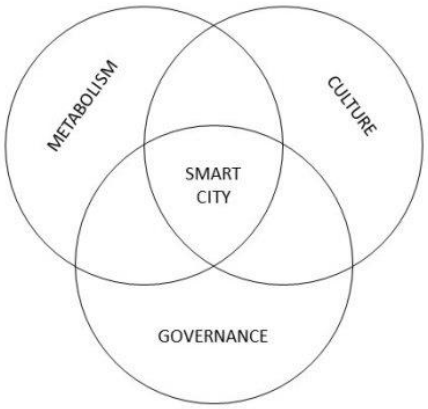

Figure 10. The proposed Smart City framework supporting dimensions of Culture, Metabolism and Governance.

This model places the human values dimension at the core of urban Smart City policy. It is able to replace the kind of trickle down approach that Smart City policies have been using based on a belief that ICT will somehow automatically lead to the right outcomes and avoid the wrong ones. This is likely to lead to the fulfilment of the U.N.'s SDG agenda rather than viewing the agenda as secondary to new smart technology. Each of these three factors overlap in their ability to create a better notion of a Smart City.

6.1. Culture

In urban terms, culture can include urban cultural heritage [66] or urban creative industries [67] or can also simply mean a focus on the needs of the citizen by promoting livability within cities. All three elements are considered part of culture in this framework and all three can benefit from ICT if constructed to do so. This would therefore create something that could be called smart culture.

All three dimensions shown in Figure 10 provide possible viewpoints for urban policy. Urban policy can be viewed through a cultural dimension [50,68,69] and this approach is recognized by UNESCO [70], which views cities as cultural microcosms that cater to innovation, creativity, and economic development while ensuring access to the highest standards of healthcare, education, and social facilities [48,72].

Cultural heritage is an industry that can contribute significantly to the economic growth of a city as millions of visitors are drawn to cultural events, art galleries, monuments, and even historical centers and museums [66]. The potential that cultural heritage represents must be revamped by adopting pervasive solutions that lead to smart cultural heritage [66]. The application of smart technology to cultural heritage in cities can optimize the economic potential of these unique resources. For instance, implementation of innovative museum visitor guides within a novel ICT-based approach may enhance the user experience when visiting museums, any gallery, or even walking around historic cities. The same role of culture as a driver for sustainable development has been proposed by Rutten [67], who dissected the role of culture as a pillar of urban regeneration and highlighted the key role of creative industries in successfully revamping urban areas. This author defined creative industries as a medium of communication that conveys specific messages. These messages could be oral, auditory, or visual, originating from both individual creativity or as a result of group dynamics. Moreover, citizens are keen to acquire these creative goods or services for their meanings, experiences, or emotions they inspire in their users [67,73]. Creative industries have three main pillars: (1) arts, crafts,

and cultural heritage; (2) media and entertainment industries; and (3) creative business-to-business services [67]. Cultural and creative industries form the pillars of the cultural economy, which, in some countries, contribute significantly to economic development and jobs creation [73]. Such activity can be assisted by the use of ICT to increase its significant in any city's economy.

Culture-led urban rejuvenation is a prominent facet of cities in China [74], Europe [75,76], South Korea [77–79], Japan [80], South Africa [81], Taiwan [82], and Latin America [83]. Wang [74] highlighted that culture can play an important role in the rejuvenation of decayed urban areas. One example is the Guggenheim Museum in Bilbao which, despite attracting negative publicity due to the relatively hefty initial investment, exceeded expected return on investment and is successfully contributing to the rejuvenation of a previously decaying urban area [84]. However, the author warned that using the Guggenheim Museum as a culture-led policy can be highly risky. The success of the museum was not entirely based on its signature architecture but was also due to the continuous attempts of the Museum Director to make the project appealing to visitors [84]. ICT is part of this vision. Broader urban regeneration, through cultural industries with ICT assistance, requires partnership with local government [85]. Much remains to be completed to fully access the potential of culture-led urban regeneration and to determine how the Smart City technologies can contribute to how it shapes the future of old urban fabric [86]. Demonstrations are needed to create smart cultural heritage that is respectful of urban culture.

The overlap between smart culture and the other major parts of the Smart City framework are quite obvious. Metabolism changes driven entirely by technology will not work unless they are also part of an urban culture that must occur in both the old and new parts of cities [57]. This approach to cities is also coupled with resilience [87], Allam and Jones [88] showed that resilience must be integrated with local challenges and the impacts of climate change, which are part of an urban culture. These situations also highlight the essential role of governance in the pathway to the implementation of culture as an urban policy in a Smart City.

6.2. Metabolism

Metabolism is essentially a biological term that traces how materials and energy flow through a living system to create all the activities of life and then convert the materials into waste and the energy into waste heat [89]. Metabolic reactions ensure life is maintained and optimized. Urban metabolism builds on this analogy by showing how the resource consumption inevitably converts into waste [90], but an Extended Metabolism Model by Newman [49] showed how livability had to be integrated with the flow of resources and that the goal of cities should be to simultaneously reduce their metabolism and increase their livability. Achieving this goal can be considerably helped by ICT providing smart systems for energy efficiency, renewable energy, and waste management [57]. Data on the decoupling of Gross Domestic Product (GDP) growth and the decline in the use of fossil fuels provides evidence that these technological systems are beginning to work [91].

However, some suggest that cities are becoming a bigger part of the problem rather than part of the solution. Kennedy, et al. [92] stated that many cities are showing an increasing trend in their consumption of water, energy, and materials, leading to changes in ground water levels, depletion of resources, building up of noxious substances, and urban heat islands effects [92]. A better understanding of energy and materials flow is thus needed. To this end and to cater to the lack of high resolution data at the household level and in real-time, the introduction of sensors was suggested by Shahrokni, et al. [93]. These authors proposed an approach called Smart Urban Metabolism [94]. This model for assessing metabolism within cities has three key approaches: (1) the use of sensors at all levels, such as smart meters; (2) real-time data flow streams toward information management system (IMS) for analysis; and (3) informing different stakeholders about the actual status of metabolism through the use of pervasive technology, such as smartphones and computer terminals. Smart Urban Metabolism also provides mitigating measures to control the flow of energy, materials, and wastes.

In fact, ICT integration within cities can increase the efficiency of data analysis [95]. The informed solutions that are proposed often have a mitigating effect on sustainability issues [96].

This kind of temporal and spatial resolution can only be made possible within an ICT-infused infrastructure provided by Smart City paradigms [93]. This approach aligns with the proposal of Zaman and Lehmann [97] for promoting a Zero-Waste city concept on the pathway to sustainability.

Newman et al. [98] developed an urban fabrics theory that highlights the need to consider urban policies for three different fabrics: the old walking city, the transit city (from the late 19th century to the mid-20th century), and the automobile city (from the mid-20th century). Each have different metabolism and livability characteristics and hence need different ICT approaches to provide assistance during the transition to the next decarbonized economy, while maintaining economic productivity and human livability [99].

Smart metabolism, as mentioned here, overlaps with culture and governance to provide direction for these resource and waste technologies required for a Smart City, which also includes clear improvements in livability. Demonstrations of how Smart Cities can use smart metabolism are needed in all parts of the city, from its old centers, through medium density corridors, to new suburbs on the fringe.

6.3. Governance

One essential component of the proposed Smart City framework is governance, which is the institutional factor that transcends data analysis and management to encompass appropriate change Dixit [100]. Governance forms the central core whose responsibility is to connect citizens with businesses and the living environment to foster a culture of innovation and sustainable economic development [10,101]. Parycek and Pereira [102] highlighted the essential dimension added by smart governance to the Smart City paradigm. We outline below the implications of smart governance on the Smart City paradigm.

Smart governance is not a standalone entity only for ICT applications, but is driven by data and collaboration among all stakeholders of the city [102]. The notion of smart governance needs to be applied within an appropriate legal framework interlinked with values, protocols, and human capital showcased within the right ICT infrastructure [102]. Shukla [103] cautioned against the use of ICT devices on their own and proposed further probing into a human-centered sociological study to gain insight into the exact implications of adopting specific smart technologies for specific purposes. Such an endeavor caters to a more effective smart system of governance [103].

Walravens and Ballon [104] pointed out the challenges faced by city governance seeking to cope with fast-changing digital business platforms. These authors called for the need for good governance in Smart Cities to promote the shared interests of the city while creating accountability and trust. This approach promotes the protection of citizens' rights while adopting new technologies that can help solve multiple problems. Technology governance adds to the role of governance in Smart Cities and improves the transparency in data flow and decision-making, while ensuring that no social gaps occur in the access to shared data [104]. The role of governance further includes protocol regulation to facilitate communication between different stakeholders within the city and the external world [10,105,106]. Moreover, governance measures can encourage policies where citizens can bring value to cities through their ideas for the future or by responding to urban development [106]. This forms the essence of participatory governance [105] or citizen-centric governance [10]. Smart planning systems can enable greater visualisation of the future and create greater understanding of the implications in different scenarios [107].

The rationale behind the Smart City paradigm is frequently aimed at sustainability [1,108]. To this end, Adger, et al. [109] and Newman and Kenworthy [57] stressed the need for environmental governance that revolves around integrating economic, social, and environmental dimensions. These authors recognized the participatory role of citizens and political representatives in environmental decisions. They also underlined the complexity of the decision-making processes

for environmental issues and called for the scrutiny of governance outcomes, eventually leading to contextualized policies. ICT can help in each of these areas if it serves the processes rather than being outside.

Smart governance has many overlaps with smart metabolism and smart culture. Governing bodies are responsible for the overall implementation of metabolism and cultural protocols to ensure the smooth running of operations while integrating the ICT dimensions proposed in Smart City paradigms. There is a need to use an appropriate governance foundation, such as the Multi-level Perspective Theory, which offers multiple entry points and allows governing bodies to choose the level at which to introduce the socio-technical change to optimize integration [110]. A Smart City, like any city that needs to change, is likely to require systemic transitions that involve a co-evolution of factors like technology, culture, and governance. As such, a multi-level perspective enables the analysis of these interactions, which then highlight drivers, potential hindrance, and implementation pathways [111].

7. Urban Economy and Smart Cities

The proposed framework highlights that the economic dimension does not require its own focus in the development of Smart Cities, but underlies each of the three dimensions of smart culture, smart metabolism, and smart governance. If, however, Smart Cities progress through isolated ICT branding exercises, economic development may be undermined, just as isolated technologies for energy or transport can undermine cities if not considered as part of the sustainability agenda [112].

The New Urban Agenda that was adopted by the U.N. in 2016 suggests that the urban economy's role is the promotion and consolidation of policies and strategies essentially aiming to develop the economic potential of a city in terms of wealth, job opportunities, and economic resilience. However, the focus aims at economic growth to create equal opportunities for its citizens while empowering municipalities to create a conducive environment for increased work opportunities within an enhanced livability setup [113]. Without this kind of "inclusive, safe, resilient, and sustainable" economic growth, cities can collapse [57,114,115].

Harrison and Donnelly [116] reflected on the rise in popularity of the Smart City paradigm in the late 2000s. These authors concluded that the actual drive toward adopting smart technology, such as those proposed by the technology giant corporations, was not entirely focused on economic outcomes, but rather attempted to achieve a more simplistic approach to economic development. This may undermine economic development. Such a cognizance occurred in the post-economic crash of 2008–2009 when administrative councils of cities realized that, due to the digital culture of the Internet and globalization, they were in direct competition with peers from all over the world [116].

Economic performance is intricately linked to political, institutional, and legal environments. These three dimensions compose the core governing infrastructure of a country or a city [117]. We further postulate that governance infrastructure influences the investment macrocosm, which is so important in providing better opportunities for economic growth. Moreover, Dixit [100] defined economic governance as the intricate interconnectivity between social and legal institutions that back economic activities and transactions, principally by providing the right framework to: (1) protect property rights, (2) enforce contracts, and (3) promote collective action to maintain organizational infrastructure. The only method to achieve this conducive environment is through good governance [100]. Thus, unless we have a framework for policy making that places ICT into smart governance, smart metabolism, and smart culture, we are unlikely to obtain the best economic outcomes.

This approach offers insights on every aspect of economic development. For example, smart metabolism offers insights into the energy usage, waste generation, and water use transitions within different parts of the city, while also increasing the livability for urban residents and city users. Livability also promotes city growth [118,119]. Giap, et al. [120] highlighted the ability of livability and

culture in cities to attract human capital and investors, leading to a positive contribution to a resilient and robust economy that also enhances socio-cultural innovation and lifestyle.

Several key strategies have been proposed to achieve these inclusive and sustainable economic development goals for cities, such as those outlined by the U.N. For instance, there is a particular emphasis on participatory and collaborative governance of local authorities with regional, national, and even key strategic international partners to promote tailor-made policies that encourage innovative sustainable economic solutions [121,122]. Productivity and competitiveness are two major foci of such strategies. These can be further enhanced if they emanate from capacity building using the city's own resources. UN-Habitat [123] further emphasized the need for empowering youth in cities and guiding them toward developing entrepreneurship attitudes based on proven business models adapted to their needs within the city. Such business opportunities must be provided by strategic partners, where strategies can be oriented toward increasing productivity and decreasing unemployment. In every case, a role for smart technologies exists to assist in their achievement.

New smart technologies and systems are being developed for transport with a strong emphasis on autonomous vehicles; however, applying these technologies to better uses is possible by creating new transit systems along corridors and in local shared mobility transit that enables much broader social and environmental goals as well as the productivity gains from the implementation of new technology [124]. A Smart City with considerably improved economic outcomes could emerge with almost no need for private vehicles and improved accessibility if the values of the city were allowed to drive these smart technology options.

Siegel and Kariuki [124] showcased an example from Kenya where the government, in order to address sustainable development and access to adequate public services, encouraged partnerships between distinct economic states, governments, and U.N.-Habitat. The collaborative endeavor depicted the numerous benefits for cities struggling with economic resilience and sustainable development. For instance, the U.N.-Habitat/Kenya partnership demonstrated the need to develop an objective baseline that offered clear guidelines on dimensions that had to be monitored. This approach prevented biased decision making and ensured the integrity of the sustainability of the projects being proposed. Moreover, the collaboration promoted sustainable exploitation of the inherent resources of each county. For Homa County in Kenya, this was in the form of technical expertise and latent financial resources that could be optimized through a multi-level regulatory procedure. These control mechanisms provided feedback to governing bodies about how to anticipate and recalibrate business maneuvers to ensure optimal gains [124]. Although only using basic ICT technology, the same kind of approach to economic development is likely to work in the Smart City framework.

Another example is the Mauritian model of economically incentivizing urban development [125], which underlines how a series of fiscal incentives aimed at the private sector can effectively catalyze attracting both investment and talent. The Smart Cities Scheme [126] proposed by the Government of Mauritius (outlined in Figures 6–9) successfully attracted new developments in greenfield sites and ensured that each emerging Smart City hosts their own niche innovative cluster. This secured Smart City promoters with their own economic model by reducing competition between Smart Cities [22,125,126]. The economic success of Smart Cities in Mauritius, however, as outlined in this paper, require stronger emphasis on smart culture in the old city areas, not just in greenfields. Smart metabolism (as in all cities) and smart governance should outline how ICT can be a part of multiple economic development strategies, instead of being a stand-alone ICT policy.

The critique of Smart Cities has also focused on the limited methodologies used to report investment returns from Smart City technologies [104]. All urban policies are meant to address urbanization issues and to improve the livability of cities, but Smart City policies are, for some reason, often left out of such transparent accountability [15]. This may undermine the Smart City concept as economic accountability will ultimately be needed to shape any policy for the future of cities.

8. Conclusions

The notion of Smart Cities is a major part of how cities across the globe are approaching the future. In the academic literature and practice, Smart Cities are generally focused on heavy investment in state-of-the-art ICT, especially ICT-based sensors, to offer big data that will be analyzed in real-time to lead to informed decision-making. However, some studies have warned about the branding exercise being laid out by Smart Cities' suppliers that are essentially promoting a one-size fits all model without considering broader economic development policies. The history of cities often includes technological change being allowed to build the future as a stand-alone policy and finding that serious issues emerged [36,37]. As such, this study proposed a new framework to optimize the use of ICT as part of the solution to problems rather than causing additional challenges.

The proposed framework aimed at redefining the Smart City paradigm by focusing on the three pillars of metabolism, culture, and governance. Metabolism provides a better understanding of material flows and may be the pathway through which new smart technology can be introduced at the household level, as well as helping to address the massive issues of climate change, traffic, recycling, and other environmental issues, while simultaneously improving livability and economic performance. This would then be known as smart urban metabolism. Cultural and historical attributes of cities create unique and special urban areas for local communities and visitors. Culture can also be a special driver for regenerating economic growth; ICT can enable uniqueness and special qualities to be generated as part of a smart culture approach. Governance shapes economic development in cities and ICT needs to be part of the general approach to improving inclusivity while providing the city with opportunities to change; this would be smart governance. These three elements of a good city are interacting and need to be addressed together.

Thus, the proposed framework provides an alternate vision of a Smart City that goes beyond ICT, allowing it to be a part of the values that cities need to create their future.

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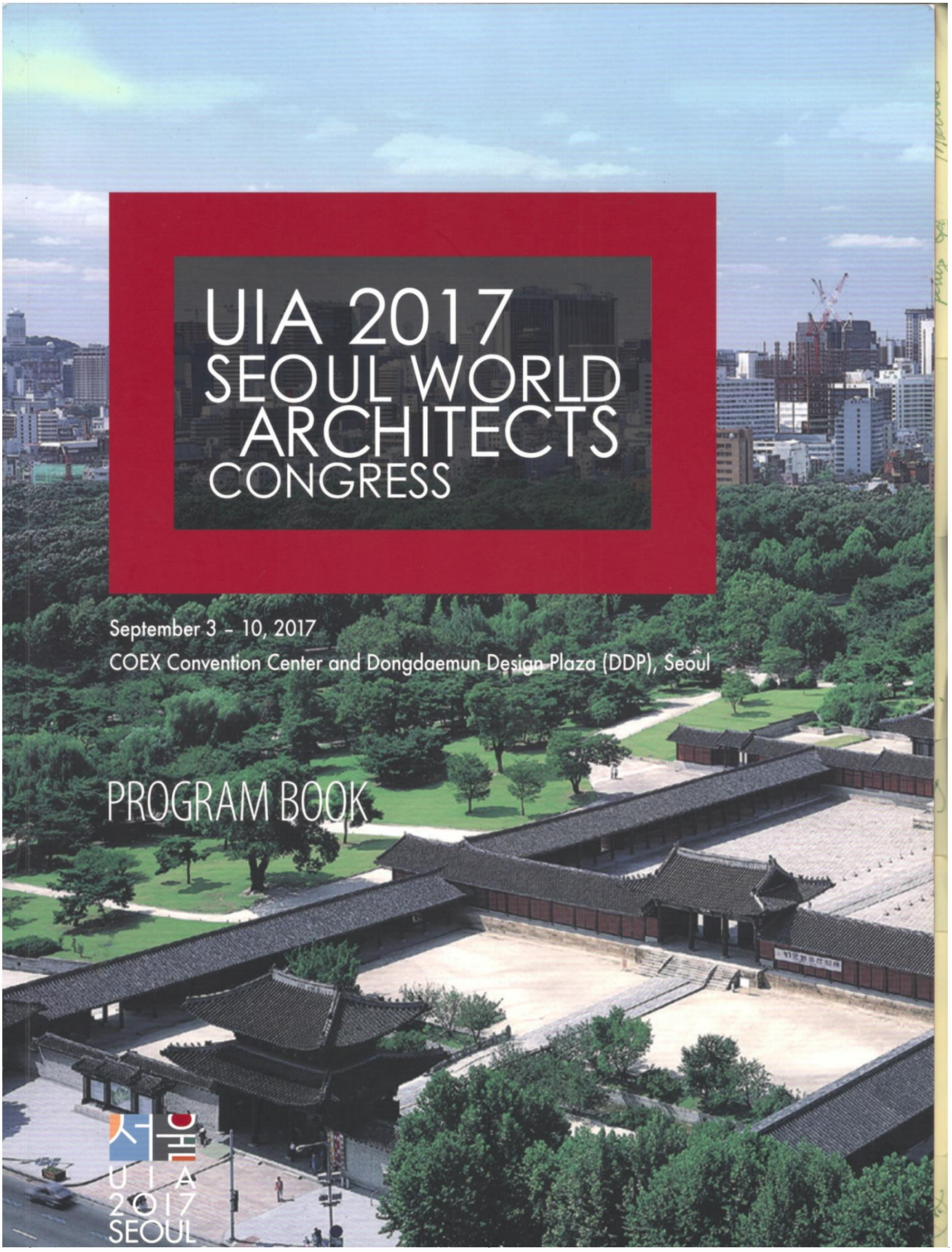
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Culture as a Driver for Sustainable Urban Development.

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Abstract

The world is witnessing an inexorable mass exodus away from rural areas towards cities. Urban population has already exceeded that of rural areas and it is being acknowledged by various learnt sources that sixty-six percent of the world population will be living in urban areas by 2050. Such relentless global urbanisation will eventually trickle down to paramount stress on the environment. Nonetheless, the last three decades have been marked by a cognizance of the need for urban sustainability to circumvent any urbanisation-linked ecological cataclysm. Besides classical pillars of sustainability in terms of the i) economic, ii) social and iii) environmental dimensions of cities, the cultural dimension of metropolitan areas have been acknowledged by the United Nations as a driver for urban sustainability. This study, therefore, sets forth to highlight such a role of culture. It is found that, indeed, culture has a preponderant role to play in terms of promoting inclusiveness within culturally diverse cities in a globalised world. This inclusiveness promotes more humane societies and tap into the potential of culture as a green economy driver. Moreover, culture can revamp overlooked urban spaces and foster sustainable development through creative industries, hence promoting liveability within cities.

Keywords: Urbanisation, Sustainability, Culture, Driver, Liveability.

1. Introduction

It is being highlighted in major reports and from various learnt sources that in the years to come, most human beings will be living in urban areas. The United Nations (2014) estimate that 66% of the total human population will be living in cities by 2050. Such a huge exodus towards the metropolitan areas will undoubtedly lead to an inexorable increase on resources demands such as water and electricity. For instance, according to Wu, J. (2010) cities are already accountable for 80 % of total carbon emissions, 60 % of domestic water consumption and 80 % of wood use for industrial purposes. The mass movement towards urban areas will also be accompanied by serious downfalls in terms of ecological impacts (Wu, J., 2010), hence highlighting the need for sustainability. There has been many studies probing into the: i) economic (Gibbs, D., 1997; Fitzgerald, J., 2010; Huang, S.L. et al., 1998), ii) social (Dempsey. N. et al., 2011; Munda, G., 2006; Porta, S. and Renne,J.L., 2005) and iii) environmental (While, A. et al., 2004) dimensions of cities as being the main pillars that act as driving forces for sustainability. However, urban sustainability can also be viewed through a cultural dimension (Garcia, B., 2004; Tweed, C. and Sutherland, M., 2007). Such a role for culture has been acknowledged rightfully by the United Nations in Goal 11 of the Sustainable Development Goals (SDGs). Moreover, novel cultural dimension, owing to globalisation, is being infused into

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the very soul of urban living (UNESCO, 2016). Culture, thus, offers the promise of driving human population even further into their venture towards upgrading their urban life without jeopardising the due rights of future generations. There has been relatively fewer previous research that focus on culture as a driver for sustainable urban development as compared to the other three pillars of sustainability, hence justifying the very rationale of this paper.

This study, therefore, aims at reviewing the different facets of cultural dimensions of cities which can act as drivers for sustainable urban development through a systematic review of published data. The methodology used for this systematic review involved an inclusion criteria that selected papers based on the relevance to the theme under study and official documents from respected and internationally acclaimed sources such as UNESCO. The findings of this study will offer groundworks to develop a framework that will highlight the use of culture as a driving force for sustainable urban development.

2. Theoretical background on Culture in Urban development

A venture such as this one needs a clear definition of 'culture' before exploring how such a facet of human civilisation can be a core driver for sustainable urban regeneration. In fact, Nurse, K. (2006) posits the narrow definition of culture has been a barrier to wider exploration of such a field in developmental debate. Nonetheless, Williams, R. (1983 cited in Nurse, K. 2006) highlighted that there are at least four facets towards defining culture; i) a developed state of mind, ii) the cultural processes such as cultural activities and interests associated to this development of the mind, iii) the actual means of these processes in terms of 'the arts' and 'humane intellectual works' and iv) as an integrated way of life with specific social order and lines of communication and experiences. For the need of this study, culture is being defined as an amalgam of all facets of Williams' definition. Such an approach ensures that culture is perceived within broader dimensions. In fact, as preconized by Nurse, K. (2006) there is need to go beyond the notion of preservation 'the arts' and 'cultural identities' so that culture is viewed upon as an underlying force towards sustainable development. .

Armed with such a broad definition of culture, it has been seen that the past few decades has been accompanied by a wave of urban generation through culture-led policies within the heart of cities. For instance, 'arts-led' regeneration was initiated in American cities and eventually the trend reached Europe (Garcia, B., 2004). However, Garcia, B. (2004) highlighted that diffusion of such initiatives within city governance have not been prominent and consistent enough. The main reason posited by the author lays the onus on the high investment cost and lack of proper coherent strategies for such endeavours. Nonetheless, culture adds vibrancy to the very fabric of what urban life is all about. It is a dimension that promotes the humane side of an, otherwise, concrete jungle (UNESCO, 2016).To further substantiate this claim, Irina Bokova, director general of UNESCO, extols the importance of culture as a driving force for sustainable urban development in her foreword in a global report on culture for sustainable development (UNESCO, 2016). It should be noted, however, that such an endeavour relies on effective policies and solid framework embedded within the core of sustainable urban governance (UNESCO, 2016). To such an effect, there is need to consider the essential dimensions that culture adds to city life.

3. Culture and People-Towards inclusive and humane societies

Cities are viewed as cultural centres which foster innovation, creativity and economic development where one can aspire to have access to state of the art social, health and education systems (UNESCO, 2016).The endeavour towards establishing culture within the very core of urban rejuvenation passes through its human dimension. One of the most important aspect of human dimension within the city is the concept of liveability (Newman, P.W., 1999). Liveability is associated essentially with a decrease in violence, crime rates and transport related casualties but also with an increase in green spaces, pedestrian friendly spaces,

educational attainment and locally available leisure opportunities (Newman, P.W., 1999). However, this liveability dimension is under threat as it is being highlighted that urbanisation has also been accompanied by mushrooming of slums. These areas within the periphery are characterised by poor infrastructure and lower access to basic services. Nearly one billion human beings live in slums nowadays and this number will soar to three billions within the next thirty years (UN-Habitat, 2016). If this situation persists it will trickle down to urban unrest and even violence. In fact, urbanisation and poverty have been singled out as being the main criminogenic forces within a society (Flango, V.E., and Sherbenou, E.L., 1976). Moreover, UNESCO (2016) recognises that poverty is intricately linked with the practices, standards and social values within a society rather than the simplistic definition of lack of material resources.

For Instance, Duxbury, N. et al., (2016) elaborated on the role that culture can have in rejuvenating cities in terms of a more humane and inclusive society. These authors hailed culture as being the nexus that brings together citizen participation and social cohesion while accelerating inclusiveness of newcomers. They also provide explicit example where such an endeavour has been a major success among citizens. For instance, the Jeju province in South Korea has elaborate cultural policies which foster an interconnection between nature and culture while at the same time promote a connection between traditions and creativity. Similar cultural policies are being used through major cities towards inclusive and humane cities; Milan in Italy proposes the 'Forum della citta mondo' to connect migrants groups, Tamaulipas in Mexico has cultural groups that contribute to social cohesion, Kelowna in Canada promote creative projects which foster cultural rootedness and inclusiveness of newcomers within historical and ecological dimensions of their new locality. In Port Louis, the capital city of Mauritius, there has been an introduction of a cultural concept called 'Port Louis by Light' where people from all cultural backgrounds come together as a common front of artists, businessmen and inhabitants/visitors to revamp the city through mural arts, late night shopping, local crafts and culturally diverse culinary exchanges (Porlwi, 2017). Such endeavours indeed highlight the role that culture has as the connecting nerve which links the individual to the society. Culture, thus, serves as the driver that brings forth enhanced liveability (UNESCO, 2016).

4. Culture as an economy driver within a sustainable setup

The economic contribution of culture to global economy can no longer be ignored but should be consolidated as an avenue to boost any country's economy while upgrading the quality of life within cities. To such an end, Ernst and Young were commissioned by the Confederation of Authors and Composers Societies (CISAC) to investigate into the very core foundation of culture as an economic driver. The findings show an extremely potent pillar which can used to consolidate dwindling or fragile economies. For instance, it was concluded that the cultural and creative industries (CCI) generate US$ 2 trillion of revenues and 29.5 million jobs worldwide. Such staggering figures, if seen in perspective, highlight that they are more than India's GDP. These figures also exceed revenues of telecom services worldwide despite telecommunication being the top notch income generator globally. The CCI sector is booming with the top tiers of employers being in visual arts, books and music. However, such a field employ only 1% of the world's active population (Ernst and Young, 2015). This calls for setting up of talent incubator centres, of art academies and urges for proper recognition of cultural identities within any urban development or regeneration policy.

The hallmarks of culture goes well beyond artisanal products as it is rather well anchored within this digital era. For instance, CCI contributed US$200b to global digital sales in 2013 while cultural goods consolidate their position among the highest income generator with US$66b in business to consumer products (Ernst and Young, 2015). Such figures consolidate the potential that culture can have in driving economy towards sustainability. On a more predicative approach, the report also highlighted the immense niche that prevails for development in CCI sector within Latin America and Africa together with the Middle East. Development in this field do not follow the same trend as in other sectors but is rather young, inclusive and entrepreneurial in

approach (Ernst and Young, 2015). For instance, Ernst and Young (2015) extols the capacity of creative culture based industries to employ more young people (15-29 years) and more women (more than 50%) compared to other sectors which bet predominately on experience and are, at times, gender biased. On the same line of thought, Hesmondhalgh, D. and Baker, S. (2013) hailed CCI industries as being a hub for creativity and hence, foster entrepreneurial endeavours. This claim is consolidated by the finding of Ernst and Young (2015) who highlighted the fact that in the US that there are 3.5 times more self-employed artists as compared to other fields. Such an approach can ignite a sustainable urban rejuvenation as has been so elegantly proven in Itaewon, Seoul. In fact, Kim, J.Y. (2016) highlights the impetus and activation energy that cultural entrepreneurs has provided in rejuvenating the camp town of Itaewon in central Seoul. The endeavours of such cultural labour force morph the town into a vibrant space while at the same time promote a culture of self-awareness (Kim, 2016). Furthermore, Duxbury, N. et al. (2017) highlight the need to develop a cultural policy for sustainable development having as primary objective "to 'green' the operations and impacts of cultural organisations and industries. For instance, the City of Lyon in France developed their Opera House within clearly laid environmental guidelines while a set of ten indicators have been developed and laid out within the Cultural Facilities Plan of Catalonia in Spain. Such endeavours, ensure that any cultural facilities are set up within an environmental friendly environment (Duxbury, N. et al., 2017).

5. Culture and globalisation

The world is witnessing a mass movement towards urban cities and from a sustainable point of view there is need to foster new life philosophies for enhanced liveability. Globalisation has led to a merging of people from all backgrounds and culture within metropolitan areas. This unique blend of cultural identities offer the vibrancy that city life is all about. However, the question remains about how the different cultural backgrounds can be merged into a driving force for sustainability and urban rejuvenation in this globalisation era. UNESCO (2016) acknowledged the potential loophole that the impact of globalisation can have on local cultures in terms of a uniformity blend. However, in this globalised world where intense competition and mass human transit are the main hallmarks, there is a unique opportunity to put forward the unique cultural assets within the city. These assets will offer opportunities for inhabitants of metropolitan areas to work in close proximity with policy makers in a bid to sustain their cultural heritage and rejuvenate local culture to promote economic growth. Such an endeavour promoted the concept of cultural tourism which account for 40% of world tourism revenues (UNESCO, 2016).

However, one downfall of globalisation can be linked to shrinking cities where people of various skills leave smaller cities and move to huge metropolitan areas. Such out flow of human resources takes away a potential entrepreneurs pool out of the smaller cities (Martinez-Fernandez, C. et al, 2012). Culture promote entrepreneurship and such an opportunity paves the way for revamping cities in a sustainable way (Nakhaie, H. and Zadeh, A.E., 2011). Such an approach will prevent smaller cities from shrinking. However, rapid urbanisation pose a serious threat to traditional way of life and may even lead to an erosion of the authenticity of cultural fabric of cities in favour of trade while increase in housing and gentrification can lead to displacement of citizens (UNESCO, 2016). Hence, it is of utmost importance to develop the right policy that will tap into the untold potential of globalisation and cultural heritage that can trigger urban rejuvenation.

6. Culture within the culturally diverse city

Globalisation and emerging geopolitical patterns are moulding the very identities of cities. These two factors are causing a mass movement of migrants towards cities. Such a situation has trickle down to very dense urban set up with a unique blend of human beings from various cultural backgrounds. This uniqueness that migrants bring to cities can be seen as an untapped well of skilled professionals and culturally rich individuals that can trigger a revamp of urban set ups. However, there is always another side of the coin

where xenophobia, racisms, and marginalisation of minority groups are more than ever present on the fore front. UNESCO (2016) urges the need to acknowledge cultural diversity as a driving force for urban regeneration. There is thus the proposal of promoting each and every culture within the hallmark dimensions of the city. This will prevent segregation and promote inclusiveness. Cultural spaces such as parks and art galleries offer such a possibility for each and every culture to be rightly acknowledged and gear the city towards social integration, cooperation and solidarity. As such, according to Baniotopoulou, E., (2001) culture also offers the possibility to change the identity of societies. This author further substantiate his claim by highlighting the trend that led to setting up of modern art museums in different cities in an attempt to revamp their image. Examples of such a trend include art centres such as the Centre Georges Pompidou in Paris and Massachussetts Museum of Contemporary Art. This kind of movement also led to setting up of more specialised, strictly defined, museums like Los Angeles Museum of Contemporary Art, the Museu d'Art Contemporani de Barcelona and Tate Modern in London. In the city of Ouagadougou, Burkina Faso, there is the Reemdoogo Music Garden which have clearly developed educational and cultural programs for the youth. Such a program aims essentially at promoting social cohesion within a culturally rich urban setup (Duxbury, N. et al., 2016).

These cultural facets offer the dimension of solicitude to the plea of the less gifted by offering avenues for income generation and jobs creation. One further example could be seen in Bilbao, Spain. The construction of the Bilbao Guggenheim Museum provided the city with a unique opportunity to revamp itself. Such an endeavour caused a major transformation in the city of Bilbao from a decaying industrial city into a *cultural mecca* which ignited a huge cultural tourism economic boom (Cunningham, E., 2016). However, such an endeavour was considered as extremely risky by many economic advocates within the Basque City of Bilbao (Plaza, B., 2006) but nearly two decades later, the Guggenheim Museum is still a booming attraction with major economic turnover (Basque Country, 2015). For instance, in 2015, there were 1,103,211 visitors at the Guggenheim Museum and this is the second best year since the opening. This figure shows a 9% increase from 2014 and from an economic perspective, it is seen that the Museum contributed 320.2 million euros to GDP in 2015. Moreover, there has been an additional tax contribution of 49.3 million euros by the museum while maintaining 6,875 jobs in 2015 (Bilbao, 2016).Moreover, there is always room to tap into the uniqueness that each cultural identify has to offer be it in terms of cuisine, crafts, creative arts, music and literature. To that end, there is need for policy makers to consider inclusive economy and social integration protocols so that culture can fully be highlighted as a major driving force for sustainable development.

7. Conclusion

This study probed into the role of culture as a driver for sustainable urban development through a systematic review of published papers and official documents. It is found that besides the economic, social and environmental pillars of sustainability, culture has a prominent role to play as a driver for sustainable urban development. For instance, culture is seen as promoting liveability within cities through social inclusiveness and citizen participation in cultural, economic and social activities of cities. Moreover, culture based creative industries are major economic booster which generate revenues amounting to US$ 2 trillion while offering jobs opportunities within culturally diverse cities. However, there is still need for further studies to probe deeper into how culture can be infused within a comprehensive framework to help cities use this relatively novel pillar for sustainable urban regeneration.

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Identified Nodes for Smart Urban Regeneration

Focus Group Findings from the City of Port Louis, Mauritius

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ABSTRACT

Although the Government of Mauritius branded a 'Smart Mauritius' initiative, there has been no effort to smart existing cities. The emergence of new cities supported by strong governmental fiscal incentives are leading to an environment of increasing urban competition with existing cities. The city of Port Louis is being challenged to attract and retain business. The fiscal incentives pose an unfair competitive business advantage for commercial operations in new smart cities. Coupled with Governmental policies to relocate administrative functions away from the capital city, this economic environment that supports a slow urban decay of Port Louis. This study showcases the findings from a Focus Group discussion, aimed at finding recommendations for smarting the existing city of Port Louis, while identifying and supporting avenues for Urban Regeneration. 31 participants from public, private and foreign institutions in the fields of Urban Planning, Urban Governance and Policy making were invited for this study and the findings reveal six emergent themes that need to be coupled with fiscal incentives for regenerating the urban fabric of Port Louis.

Keywords: Port Louis, Urban Regeneration, Focus Group, Fiscal incentives, Strategic assessment, Smart City

1. INTRODUCTION

Since Independence in 1968, Mauritius has been able shift economic policies very quickly. This ability has been hailed by economists such as Paul Collier [1] as a trait that many countries lack, and this has much to do with the small size of the island. While Port Louis was an economic driver for the country for centuries, and has benefitted greatly from economic expansion and diversification [2], it has nonetheless suffered from the recent policies aimed at the decentralisation of activities, leading to the emergence of new cities [3]. Those new cities, branded as Smart Cities, were supported by a valid framework, released in 2015 [4]. The framework incentivises investment in greenfield, previously sugar cane land, to encourage the creation of emerging cities. While this approach of building emerging cities has been criticised by some [5], Mauritius hosts a high urban density rate where its infrastructures are failing to support demographic increase in population size [3].

While the Government of Mauritius branded the 'Smart Mauritius' initiative, there is only a predominant focus on emerging cities. Existing cities, like Port Louis, the capital city, is being criticised as being neglected [6]. Government moreover plans to relocate the administrative functions away from the city, as well as the police headquarters [7]. The Government is also planning its own Smart City; Cote d'Or, which hails to brand itself as the new administrative city of Mauritius [7].

It is believed that the emergence of new cities will bring an increased competition to existing cities [8]. This will pose a challenge to Port Louis to retain and attract business, thus challenging its role as the economic capital of the island. Moreover, there have been numerous headquarters, employing thousands of people, that have expressed interest to relocate to other Smart Cities [9]. With both the private and public sector losing interest in investing in the capital city, it is being expected that the city falls in decay [10]. It is believed that an increased cooperation from both the public and the private is required for the regeneration of urban fabrics [11]. This is further supported by the fact that the Municipality of Port Louis spends over 95% of its budget for administrative reasons and have little left to invest in infrastructure or services to the city [9].

Over the years, there have been numerous proposals for uplifting Port Louis [12], but the lack of public funds and lengthy administrative hurdles have been blamed for the failure of urban regenerative and urban embellishment measures [13]. The role of the private sector is being hailed as a potential solution to the regeneration of the city [14]. However, it was noted that the political climate in Mauritius does not foster an environment conducive for investment [15].

Most literature is seen focussing on social and technical challenges and dimensions for urban regeneration, and their relationship with urban economics and governance has not been widely

researched [16-18]. There is also little research on the Mauritian sphere on how to engage in both the question of urban regeneration and approaches to smarting an existing city from the viewpoint of professionals and leading actors in the field.

This paper focuses on the city of Port Louis from the perspective of smart urban regeneration while engaging in urban economics from both a demand and supply side.

2. LITERATURE REVIEW

The concept of smarting cities is not a new, and originates from Urban Planners and Engineers, dating back a century, seeking to measure the city [19]. Another study highlight the application of computer modelling previously used for wars into better urban planning in the immediate years following the last world war [20]. Nonetheless, the concept of smart city is gaining momentum in literature and is the most conspicuous urban design being under scrutiny to solve urbanisation-linked ailments within this digital era [21, 22].

Despite much hype surrounding such a notion of urbanisation, a clear definition is lacking [23, 24, 25] reviewed proposed definitions for smart city and highlighted the intricate web of different dimensions being included in these definitions.

Author/s	Definition
Giffinger [26]	A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens.
Hollands [27]	A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens.
Harrison [28]	A city "connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city"
Council [29]	A city striving to make itself "smarter" (more efficient, sustainable, equitable, and livable)

Toppeta [30]	A city "combining ICT and Web 2.0 technology with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, in order to improve sustainability and liveability."
Washburn et al. [31]	"The use of Smart Computing technologies to make the critical infrastructure components and services of a city—which include city administration, education, healthcare, public safety, real estate, transportation, and utilities—more intelligent, interconnected, and efficient"
Setis-Eu (Cited in Cocchia [32])	"Smart City is a city in which it can combine technologies as diverse as water recycling, advanced energy grids and mobile communications in order to reduce environmental impact and to offer its citizens better lives"
Dameri [33]	"A smart city is a well-defined geographical area, in which high technologies such as ICT, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development"
Northstream [34]	"Concept of a Smart City where citizens, objects, utilities, etc., connect in a seamless manner using ubiquitous technologies, so as to significantly enhance the living experience in 21st century urban environments"
Hall [35]	"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens"
Su Li [36]	"Smart City is the product of Digital City combined with the Internet of Things"
IBM [37]	"Smart city is defined by IBM as the use of information and communication technology to sense, analyze and integrate the key information of core systems in running cities"
California institute (2001 cited in Cocchia [32])	"A smart community is a community that has made a conscious effort to use information technology to transform life and work within its region in significant and fundamental rather than incremental ways"

Table 1. Definitions of smart cities (Adapted from Chourai et al. [38] and Cocchia [32])

Academicians are increasingly concerned about the central role of governance within a smart city framework [39]. Paskaleva [40] highlighted the collaborative role that e-governance is expected to play in a smart city framework in a bid to promote competitiveness and to cater for establishment of knowledge based networks. Nam and Pardo [41] also stresses on the collaborative nature of smart governance which must also cater for citizen empowerment. Citizen engagement through a data-backed and informed governance can trigger economic growth [42]. Such a vision leads to the consideration for 'smart people' which forms another important pillar of a smart city framework.

Smart people form the social and human capital of a city and they are its creative force [43]. However, Parycek and Pereira [44] call for the need of an appropriate legal framework for smart governance implementation within the city. These authors also highlight the need for the framework to be infused with values and protocols which focuses on the human capital of the city but within the inherent ICT-based dimension that smart city offer. Shukla [45], however, proposes human-centredfon introduction and use of ICT based media to ensure effectiveness of the smart city governance.

Al-Hader and Rodzi [46], on the other hand, highlight the need for a smart infrastructure as the initial step in proposing any smart city framework. These authors extrapolate the need for this dimension to monitor operational metabolism of the city to optimise resources use and processes. This view is joined in Balakrishna [47] who also proposes three key indicators for smart infrastructure in the form of i) real world awareness of the potential of big data capture ii) knowledge engineering to convert big data into exploitable ones and iii) interconnectivity which promote knowledge sharing.

Despite the relative diversity of dimensions that occur within smart city frameworks, it is essential to understand that the role of smart city is to make cities more sustainable [21] and more liveable [48]. Newman [49] highlights the need for liveability through a better management of materials and energy flow within the city. This idea is further expanded by authors [50] who proposes a Smart Urban Metabolism which is essentially the use of sensors at all levels of a city to provide real time data of materials and energy flow so that the right decision may be taken to ensure optimisation of metabolic processes within the smart city. Berardi [23] go even further and link sustainability with the need for optimisation of natural resources, hence the call for more people-centred metabolic processes. To this end, culture offers the key dimension that can promote innovation, creativity and liveability [48].

2. RESEARCH DESIGN

The focus of the study was to underline the viewpoint on urban regeneration for the City of Port Louis and this work did not focus on challenging views to engage in group debates. As such, research based on in-depth group work was selected and focus groups were organised to regroup professionals from various fields, as well as city leaders, to engage in an informal discussion. One full day workshop was organised where five focus groups were conducted in the city of Port Louis, 2018.

2.1. Focus group method

This study adopts a focus group methodology. This approach is well documented as a reliable and cost-effective method for qualitative data gathering in both public and private organisations [51]. For Parker and Tritter [52], participants in a focus group are engaged in the process due to a shared lifestyle

circumstance or condition. Lewis [53] also hails the robustness of focus groups in providing insights on a specific issue from a group of selected participants. As the focus group technique relies on effective interaction between the various participants [52, 53], it has been recommended that a conducive environment is fostered for interaction based on common interests. This is supported by the fact that well designed focus groups provide the researcher with the ability to observe how theories emerge in respect to the viewpoint of the participants. In this respect, it is noted that the opportunity must be provided to all participants to express their thoughts [54, 55].

Massey [56] provides a deeper understanding on the 3 key dimensions and expected data outcomes from a focus group: (1) Articulated data, where participants express thoughts from a direct question, (2) Attributional data, where the moderator discreetly provokes discussion, and (3) emergent data which refers to normative understandings.

2.2. Participants

Professionals from leading private firms in Port Louis, Members of Foreign Delegations, and High-level representatives from various Governmental Ministries, Parastatal Bodies, and the Municipality of Port Louis were invited for a full day workshop in January 2018. They were invited by e-mail, in which the purpose, the participation in groups and the course of work were duly explained. 31 professionals, representing an attendance of 85%, participated in the focus groups. Since the nature of the discussion and the high-level panel of professionals, most of the participants knew each other. The average age of the participants was 43, with the highest at 68 and lowest at 23. The collective panel represented organisations employing approximately 24,388 people, where 52% worked in the city and 73% transit through the city of Port Louis at least once per day. The panel moreover constituted of 74% from the Private sector, 19% from the Public sector and 6% from Foreign Institutions.

2.3. Data collection

The focus groups were included as part of a full day workshop with the aim to brainstorm on avenues on how to smartly regenerate the city of Port Louis. It was made clear that the contributions of the participants will bring value to the collected data that may help define a national strategy for urban regeneration which will be proposed to the Government of Mauritius in June 2018. The overall aims and objectives of the workshop was introduced at the beginning, and the participants were made aware of the techniques that shall be applied for data collection. This process falls in line as per the practices as outlines by Morgan and Hoffman [57].

The workshop was broken in 5 focus groups and general questions were provided for them to discuss. The 31 participants were then provided with the opportunity to choose which group they may be able

to contribute the most due to their field of activity, and 2 moderators were assigned to each group which had for task to note the various responses. No group had more than 12 participants, ensuring that all participants had the opportunity to contribute to the discussion.

A general presentation was delivered at the beginning, to all participants as a single group, provided the groundwork for the main issues to be discussed and highlighted later in individual groups. The following series of direct questions were then provided for them to ponder on five groups:

Group 1:

- *How do we create an inclusive and vibrant business environment for Port Louis?*
- *How to we increase urban affordability?*

Group 2:

- *How to we encourage a sustainable fabric responsive to the environment?*
- *How do we create a healthy urban fabric for Port Louis?*

Group 3:

- *How to we protect our heritage?*
- *How do we enforce the shared identity and sense of belonging?*

Group 4:

- *How do make use of technology to facilitate everyday activities in Port Louis?*
- *How do we encourage an environment where innovation thrives in Port Louis?*

Group 5:

- *How do we create a vibrant city?*
- *How to we enforce the role of the youth in the city?*

Questions were broadly defined to allow participants with the flexibility to approach key topics and dimensions voluntarily.

The moderators had for task to ensure that all participants had an opportunity to speak and to contribute productive to the group discussion. The moderators were informed to keep their

interventions broad so as not to directly influence the course of discussions and to only intervene to discreetly encourage participation, through attributional questions as defined by Massey [56].

2.4. Data analysis

The textual responses from the 5 groups were imported into Nvivo 11 for qualitative coding and analysis. Each line of text was examined for relevance, and assigned a descriptive label; referring to a code. The process of examining and labelling a code was repeated until all the relevant lines were labelled. The objective of this process was to ensure similar text was identified and coded. Responses which did not contribute to any of the 10 questions from the 5 focus groups were disregarded. This was the basis for data reduction to ensure that the findings retain a high level of relevancy. The codes were then examined with the objective of identifying similarities and for the process of sorting in clusters. The similarities and clusters were later examined to identify emerging themes.

3. Findings

Initial findings showcase that participants demonstrate an extensive innovative viewpoint while proposing and collectively designing solutions to urban issues. However, when faced with realities of local administrative regulations, there seem to be a collective sense of defeat. Moreover, it was also noted some regulations like the Landlord & Tenant Act [58] and the Aapravasi Ghat Buffer Zone [59] can be in discordance to property value and development. From a political standpoint, it was highlighted that policies are driven by short-term economic interests, with no prior consultation with economic operators of the country, and at times without consultation across governmental ministries. However, it seems that participants felt restricted by their beliefs and accepted the limitations of their respective roles through the status quo. This was surprisingly supported by the fact that they appeared more eager to elaborate on their action limitations rather than discuss on how to concretely advocate for policy changes. This further highlight the perceived realm of policies in place to alienate innovative measures.

The textual analysis revealed 112 distinct recommendations that were regrouped in 28 nodes as illustrated in figure 1.

Figure 1. Tree map showcasing hierarchy through the 28 identified nodes.

3.1. Incentives

The most frequent keyword identified is: 'Incentives', with a recurrence of 3.7% from the overall textual analysis. Table 2 showcases the frequency from the top 10 recurring keywords from the 5 focus groups as well as across.

Overall		Group 1		Group 2	
Keyword	**Frequency**	**Keyword**	**Frequency**	**Keyword**	**Frequency**
Incentives	3.5%	Incentives	2.7%	Incentives	4.9%
Encourage	1.9%	Demand	2.7%	Frontage	2.8%
Buildings	1.0%	Encourage	2.0%	Traffic	2.1%
City	1.0%	Agency	1.3%	Pavements	2.1%
Through	0.9%	Allowance	1.3%	Waste	2.1%
Activities	0.9%	City	1.3%	Encourage	2.1%
Heritage	0.9%	Business	1.3%	Owners	2.1%
Cultural	0.9%	Land	1.3%	Schedule	1.4%
Private	0.8%	Building	1.3%	Urban	1.4%
Public	0.8%	Historic	1.3%	Drains	1.4%

Group 3		Group 4		Group 5	
Keyword	**Frequency**	**Keyword**	**Frequency**	**Keyword**	**Frequency**
Incentives	3.4%	Through	3.8%	Incentives	6.8%

Cultural	3.0%	Investment	2.5%	Activities	4.1%
Heritage	3.0%	Housing	2.5%	Spaces	2.7%
Buildings	2.5%	Youth	2.5%	Encourage	2.7%
Encourage	2.5%	Food	2.5%	Pedestrianisation	2.0%
Private	2.1%	Idea	1.3%	Commercial	2.0%
Sector	1.7%	Fruition	1.3%	Developments	1.4%
Art	1.7%	Project	1.3%	Where	1.4%
Public	1.3%	Proposal	1.3%	PPG	1.4%
City	1.3%	Allowance	1.3%	Exemptions	1.4%

Table 2. Frequency of top 10 recurring words through the various focus Groups

The approach to use fiscal incentives is well documented and practiced in Mauritius. Fiscal incentives are in effect for businesses operating in the Freeport[60] and in Smart Cities[4]. It is thus rationalised that the various professionals from both the public and private sector would highlight this measure as a rational tool to catalyse Urban Regeneration supporting economic growth. It is also noted that requested incentives were aimed for: (1) the benefit of the private sector to generate revenue, and thus stay in Port Louis, (2) to generate municipal revenue for the municipality of Port Louis in the form of taxes, and (3) to encourage investment from the private sector in the public domain for public good.

3.2 Emerging Themes

Six themes, as illustrated in figure 2, are seen to emerge; (1) Metabolism, (2) Culture, (3) Collaboration, (4) Governance, (5) Business Support, and (6) Smart Infrastructure.

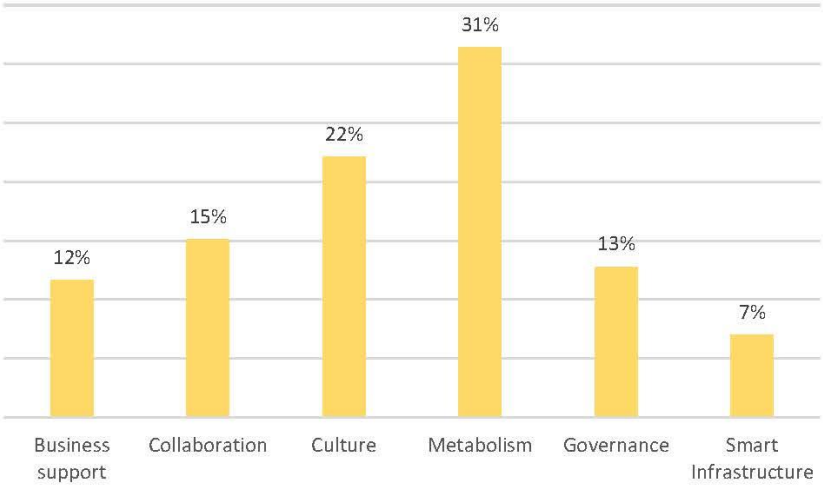

Figure 2. Six emerging themes from the focus groups

3.2.1 Metabolism

There were numerous nodes that were highlighted in the social infrastructure cluster; namely sustainability and liveability and their relevant governing structures. This cluster gained more traction as opposed to the other 2 emerging themes. There was a natural agreeing consensus that the liveability components of the city need to be first resolved and enhanced prior to the addition of smart infrastructural components. It was also noted that this cluster alone will not suffice to regenerate the fabric, as it lacked economic and governance dimensions.

3.2.2 Business Support

It was noted that public funds are allocated by the central government and that the Municipal council spends most of its funding on administrative resources. It was thus noted that revenue can be generated by encouraging the retention and attractivity of businesses. This will in turn generate revenue to the Municipal council which can then invest in embellishing the city for its residents and users. It was also noted that to create a competitive ground with Smart Cities, businesses in existing cities need to be able compete. There was also noted arguments on economic empowerment and the need to support Small and Medium Enterprises.

3.2.3 Collaboration

There is a noted emphasis on the need to enforce collaboration between public and private sectors; namely for (1) Encouraging business, (2) Better managing public assets and (3) Disaster management. Some clear examples of collaboration noted during the discussion included the revamping of Governmental assets through lucrative Public Private Partnership models; two examples highlighted were that of heritage buildings that are left in decay, and the case of commercialising pavement space for encouraging coffee shops, promenades and artists to perform.

3.2.4 Smart Infrastructures

While one of the primary goals of the focus groups were to defining approaches that include smarting the urban fabric of Port Louis, it is interesting to note that Smart Infrastructures were not noted as a primary point of concern by the participants. This is mainly since there were many other nodes that seem to require intervention prior to smarting a city; notably increasing its quality of life. In that respect, concerns relating to resilience; namely flash floods and disaster management were raised. However Smart infrastructures relation to (1) Parking, (2) IT Connectivity, and (3) Big data were also noted.

3.2.5 Culture

As the second most relevant identified keyword after incentives, culture was noticed as a potential thread through the various focus groups. Culture was brought forth in numerous occasions to highlight: (1) the need to encourage artists to perform in public spaces, (2) cultural landmarks are closed and crumbling and frameworks allowing private funding is sought, (3) culture as a branding tool, and (4) the potential of cultural digital goods.

3.2.6 Governance

The Governance nodes highlighted issues pertaining to health care, law enforcement, targeted inclusive policies, and security. It is worth noting that the other emergent themes regarding (1) culture, (2) business support and (3) metabolism were strongly emphasised in this theme. There was a general understanding that governance, more specifically in the form of targeted policies, had the capacity to regenerate key dimensions in the urban realm.

3.2.7 Summary

A summary of findings from the five groups are summarised in table 3 below.

Group	Research Question	Data Type	Main findings
1	How do we create an inclusive and vibrant business environment for Port Louis?	Articulated	It was noted that an increased environment for collaboration between private businesses and public economic policies is desirable.
	How to we increase urban affordability?	Attributional	The conversation of vacant office buildings, and the possibility to convert soon to be vacant buildings (due to smart cities) to housing units is seen to be widely sought to increase housing affordability. Incentives targeted to residential units were also noted to support retrofitting, construction and refurbishment.
2	How to we encourage a sustainable fabric responsive to the environment?	Articulated	The reduction of vehicular traffic has been widely discussed and linked to the issue of air pollution in Mauritius. Incentives for Green mobility equipment (including cycling) was noted.
	How do we create a healthy urban fabric for Port Louis?	Attributional	Urban farming and disaster management plans was proposed to increase resilience and liveability.
3	How to we protect our heritage?	Articulated	It was noted that Architectural landmarks with cultural significance are part of public assets, and there are no public funds available for their restoration.

	How do we enforce the shared identity and sense of belonging?	Attributional	Creative and cultural industries was proposed as a theme for urban regeneration, which may infuse culture in Port Louis. For this effect the private sector must see this as a profitable business venture.
4	How do make use of technology to facilitate everyday activities in Port Louis?	Articulated	A focus on smart urban management solutions was noted, supported by policy and current financial practices; like property rental and purchase schemes.
	How do we encourage an environment where innovation thrives in Port Louis?	Attributional	Innovation was highly linked with the youth, where it is understood that there is a lack in Port Louis. Incentives targeted to Innovative Startups were proposed.
5	How do we create a vibrant city?	Articulated	It was noted that infrastructures to support a 24/7 city is not present in Port Louis, namely; lighting, pavements, parking, and pedestrian friendly connections., and that there is no public funding available for providing those services.
	How to we enforce the role of the youth in the city?	Attributional	It was noted that there is a clear absence of the interest of the youth to reside in the city due to the high property prices, and due to the lack of public open space where they are free to express themselves.

Table 3. Summary of Main findings

4. DISCUSSION

It was noted that policies have the pivotal power to catalyse and drive economic development that is both inclusive and sustainable. There is literature that supports this trend in other countries [61]. However, the primary findings from this study showcase emerging nodes aimed at smartly regenerating the urban fabric of Port Louis. Interestingly, it was noted that there was a clear delimitation between business and urban economics where it was showcased that urban economics are driven in disregard with business dimensions. This goes against contemporary practices as outlined by numerous authors [62-64]. There was also a consensus that increased collaboration between both the private and public sector can bridge this gap to better design policies tailored for the betterment of the urban fabric. The need for enhanced collaboration between the public and private sectors have been hailed by many as a key dimension for development [65, 66]. Longa [67] furthermore associates the term Public Private Partnerships (PPP) closely to redevelopment.

Interestingly, out of the six dimensions highlighted for Port Louis, 4 has been widely researched by Allam [68] from an urban planning viewpoint. The 2 additional dimensions; Business Support and

Collaboration highlight the need to include business economics as a primary node for Urban Regeneration. Moreover, out of the highlighted dimensions, key areas were identified: 1. Refurbishment of existing buildings, 2. Increase of affordable housing, 3. Funding for public infrastructure, 4. Innovation through youth led ventures, 5. Smart Urban Management systems, 6. Green Mobility, 7. Creative and cultural industries.

A review of literature highlights the absence of prior research regarding smart urban regenerative methods in Mauritius. While this study does not have for aim the interpretation of findings, it shares the desired urban regenerative focus by both the Public and Private sector. The findings therefore contribute to knowledge in the field of urban planning for Port Louis, Mauritius.

Massey [56] shares that numerous uncertainties arise as to focus groups during the various stages of data collection, analysis and interpretation. While focus groups are a primordial tool to underline standards across communities, they fail to do so with statistical relevance. Thus, this study does not claim to support statistical validity but rather sets itself to spark discussions on possible highlighted avenues while dwelling in urban regeneration in Port Louis.

To safeguard validity of data, it is worth noting that the collected results from the five distinct focus groups were not cross-verified with the participants. This method is supported by Morse [69], as synthesised results are normally abstracted and participants do not have the ability to analyse data in its raw form without bias.

Lastly, the interpretation of data by the author is based on the understanding of the thematic and its relations to the broader spectrum of urban planning and local economy. This is further supported by the author's research on the subject matter and professional expertise in the field.

5. CONCLUSION

This study, based on 5 focus groups, underlines the key avenues for smart urban regeneration for the fabric of Port Louis. The findings highlight the emergence of six themes, namely: Governance, Culture, Metabolism, Collaboration, Business Support and Smart Infrastructure. These results converge with the findings of previous studies conducted by other authors, and the dimensions of Business Support and Collaboration is seen as a potential addition to the Smart Framework by Allam [68]. Even though the metabolism theme was deemed more important by factor of emphasis, it will not be favourable to

urban regeneration unless it is coupled to economic and governing structures. The need for inclusive models is also noted and there was consensus that economic fiscal incentives are to be tailored to address the six themes aimed for a smart urban regeneration. Nonetheless, the central dimension of Culture in Port Louis is expected to be the focal point from a people-centered standpoint in a bid to revamp the capital city of Mauritius. This study offers baseline data to policy makers looking at regenerating the city of Port Louis through a smart framework.

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A theoretical application of the Extended Metabolism Model in Port Louis in a bid to promote urban sustainability

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Abstract

As the world is witnessing a rise in the population of cities, there is increasing literature on the effects of urbanisation on our economic, social and environmental fabric. All of which leading to an unhealthy contribution to climate change. In this regards, sustainability in cities appear to be one of the most sought solution. With Mauritius already witnessing the impacts of climate change, the importance to turn towards sustainable cities is primordial. This paper dwells into a theoretical application of Newman's Extended Metabolism Model in the capital city of Mauritius, Port Louis. A theoretical scenario combining best practices in the various fields is proposed for Port Louis and weighted against the current scenario. In this context, the potential specific economic savings and ecological gains are highlighted in terms of energy, air, water, waste and transportation guidelines, whereby providing groundworks to urbanists and policy makers looking to revamp the capital city of Mauritius into a more sustainable urban fabric.

Keywords
Urbanism
Port Louis
Mauritius
Sustainable development

1. INTRODUCTION

Mauritius, a small island developing state, has witnessed tremendous development in the past two decades. Through the years, the island has positioned itself as a major trade hub in Indian Ocean with the capital city, Port Louis, harbouring the only trade port and acting as the main administrative centre of the island. Following the same global trend, increasing demands for residential and work areas in urban setups, especially Port Louis, have been accompanied by several tides of urban developments. However, the sustainability of these projects had a few flaws as could be witnessed by the inability to cope with environmental disasters like flash floods and major traffic issues. If such trend continues, it is undoubtedly going to lead to a hugely dense urban area with a polluted living environment.

This mass movement towards urban areas has been a relentless demographic constant ever since the industrial revolution. Grimm et al. (2008) and Wu (2010) point out that global urban population was only 2 % in 1800 and by 2007 this ratio soared to above 50 %. The United Nations predict that by 2050, 66 % of the world population would have left the rural areas to live in cities (UN 2014). Such an exodus creates a huge demand on ecological demands on the Earth's resources. For instance, cities account for 80 % of total carbon emissions, 60 % of domestic water consumption and 80 % of wood for industrial purposes (Wu, 2010). There is, thus, urgent need to address such issues in terms of energy and water demands with careful consideration for transport and waste management to prevent the collapse of Port Louis. Moreover, the capital city of Mauritius is expected to undergo further development that needs to be weaved with the fabric of sustainability within its core to ensure healthy, green and harmonious development.

2. URBAN SUSTAINABILITY

The major foundation stone on the concept of sustainability is from Brundland report in 1987. This report is the end product of the World Commission on Environment, created by the UN General Assembly in 1983, spearheaded by the then prime minister of Norway, Gro Harlem Brundtland. The major finding of the commission advocates the merging of economy and ecology in such an intricate balance that none of the due of the future generations will come into jeopardy. Such view on sustainability has also been backed by other authors (Edwards 2005; Farr 2011; Van den Berg 2007). Stead and Stead (1996) add a further dimension of intricate community based sustainability and link it to spiritual fulfilment. Sustainability is the key to ensuring a viable future and hence, justify the need to ponder on the dimensions of urban sustainability.

Literature points out that urban sustainability consists of three major pillars; i) social ii) environmental and iii) economic. These pillars are supported by several spokes that not only add depth and dimensions to the concept of urban sustainability but also highlight the urgent need for more concrete actions towards such an end. The social, environmental and economic dimensions showcased with governance forms the core of sustainability (Shen et al. 2011; Yang 2010). Furthermore, factors associated with population, income and technology are the salient driving features for such an endeavour towards ensuring viability of future generations through a sustainable approach to urban living (Parris and Kates 2003). Another distinction between the variables that dictates the urban transition has been elaborated by Raskin et al. (2002) whereby two main groups of impetus arise; i) ultimate drivers and ii) proximate drivers. The proximate drivers include popular development policy like introduction of new sustainable technologies while ultimate one includes long term issues such as mind-set change in terms of values, culture and understanding. These literature point out to a common environmental core that in the case of Port Louis revolves around energy, water, waste and transport infrastructures. Sustainability in these dimensions of the city may promote a better living environment and make Port Louis more conspicuous to investment. Equipped with an understanding of what dictates urban morphing towards sustainability, there is need to focus of a model of change for gearing Port Louis towards sustainability.

3. THE EXTENDED METABOLISM MODEL

Numerous models of change prevail in literature but for the sake of this study, the limelight is being laid on **Newman's Extended Metabolism Model due to the prime focus being geared towards upgrading the livability** within cities without compromising the resources for future generations. The concept of assigning a metabolic component to cities has first been coined by Wolman (1965) which principally englobes the input of resources and managing the wastes generated with as little impact as possible on the city. Moreover, the model of viewing cities as biological entities has its origins within the work of Tjallingii (1995) who draws lines of similitudes **between cities and ecosystems. Newman's model strengthens upon these two dimensions but lays emphasis on** upgrading livability and growth opportunities for the urban population.

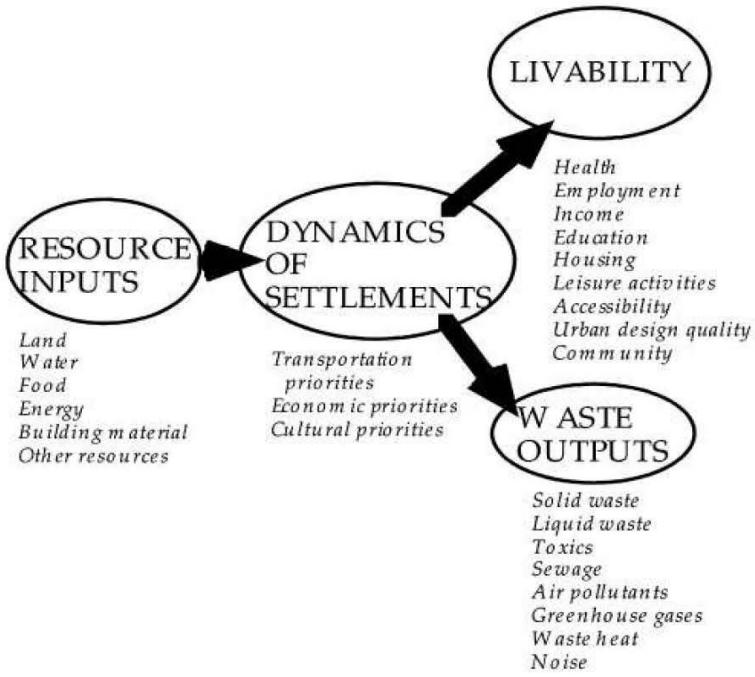

Fig. 1. The extended metabolism model of human settlements (Source: Newman, 1999)

The extended metabolism model for cities in a bid to ensure sustainability has an inherent underlying principle that links inputs to outputs like any biological system. Resources that get in will eventually come out as waste products similar to the law of thermodynamics on conservation of energy. Decker et al. (2000) further extrapolate on the concept of cities metabolising raw materials with generations of wastes while a few years later Kennedy et al. (2007) defined the metabolic processes within cities as the summation of the technical, social and economic processes occurring within cities resulting in growth, energy production and waste elimination. However, Newman (1999) highlights the need to consider the factor of entropy in such a model. The entropy factor refers to the input of energy to manage waste generated and this extra energy defeats the purpose of sustainability. To circumvent the entropy factor, Newman (1999) proposes a reduction in resources input. Furthermore, to better understand how materials flow within an urban setup and, thus, propose mitigation measures to reduce wastes generation, Sahely et al. (2003) and Kennedy et al. (2011) highlight the need to monitor materials cycling, such as wood, paper, minerals and plastics among others, in urban metabolism.

One hallmark feature of Newman's model is that cities are entirely scrutinized as a biological entity with prime focus being upon human growth in terms of availability of opportunities (Newman 1999). Such a bold underlying principle lays the onus on livability, hence providing the nerve fibre that links the environmental dimension of urban sustainability with that of economic and social dimensions. The livability component of the Extended Metabolism Model lays emphasis on the needs of human beings to be satisfied in an attempt to promote not only individual well-being but that of the whole community as well. Newman (1999) stresses on the amalgam between human environment and the natural environment as being undissociable from the very fabric of livability. This highlights the need for the focus towards sustainability to not only dwell on cutting down wastes generated by regulating inputs but should also be geared towards increasing human livability through social amenity and health (Newman 1999). Lennox and Turner (2004) also highlight the need to draw connection between urban metabolism and quality of life and thus, urge the need to consider indicators for livability in promoting urban sustainability.

3.1 Application of Newman's extended metabolism model to Port Louis

Sahely et al. (2003) point out urban metabolism analysis as being a means of compiling the input and output within urban setup in view of obtaining profiles for energy, material cycling, waste management and even structural one. Moreover, Gandy (2004) points out to the essential role that water supply, its circulation and eventual elimination hold within the very core of urban metabolism. Based on the indicators of urban sustainability with respect to the hallmark features of livability, the extended metabolism model can be infused at various levels within cities including human activities. For instance, Newman (1999) targeted primarily three areas of action; i) Industrial areas, ii) Households and Neighbourhoods and iii) Urban demonstration projects. Hence, the following prime areas of focus should be monitored in terms of input of energy, water supply and elimination, waste generated and any mitigating measure that might cut out the wastes generation part of the equation without compromising of quality of life.

3.2 Inputs vs Outputs for Port Louis

The inputs of Port louis can be considered in terms of i) energy, ii) water and iii) food/capita while the outputs considered include wastes outputs (solid/capita, sewage/capita, hazardous waste and air waste/capita as preconized by Newman (1999).Data specific for Port Louis is not available for generating a time series but it can be extrapolated from crude data for the whole Island (**Tables 1 and 2**). Energy demands and production has greatly increased with transport sector being the major consumer with 463.1 ktoe (kilotonne of oil equivalent) representing 50.7 % of the overall consumption (**Table 2**). Wastes generated (solid and sewage) and greenhouse gases liberated follow the same trend (**Tables 3, 4 and 5**). Most of the solid wastes generated is from domestic sources while the green houses gases emitted predominantly sources from transportation. Data for input of construction materials and food are not available but the former is expected to fluctuate depending on ongoing projects. The dynamics of the input form an important part of the Extended Metabolism concept and it is quite apparent that the resources input is mainly used for transport, domestic and industrial (including

business) usage. The major outputs show unsustainability of the dynamics involved for the metabolism and urges the consideration of alternatives.

Table 1. Main energy indicators for Mauritius (Source: Statistics Mauritius 2016)

Indicators	Unit	2011	2012	2013	2014	2015
Average population, Republic of Mauritius	thousand	1,252	1,256	1,259	1,261	1,263
GDP in 2000 rupees	Rs.Million	170,207	175,994	181,626	187,801	193,623
Per capita primary energy requirement	toe	1.14	1.14	1.16	1.18	1.22
Per capita final energy consumption	toe	0.69	0.68	0.69	0.71	0.72
Potable water produced	Mm^3	203	215	217	229	245
Potable water consumed	Mm^3	96	95	96	97	98
Potable water consumed per capita per day	litres	218	214	216	218	220

Table 2. Final energy consumption by sector from 2014-2015 (Source: Statistics Mauritius 2016)

	2014		2015	
Sector	Ktoe	%	Ktoe	%
Transport	454.1	50.9	463.1	50.7
Manufacturing	210.7	23.6	216.2	23.7
Household	126.5	14.2	129.9	14.2
Commercial and distributive trade	92.5	10.4	95.5	10.5
Agriculture	4.6	0.5	4.2	0.5

Table 3. Waste water generated at primary treatment plants (Source: Statistics Mauritius 2016)

Year	2010	2011	2012	2013	2014
Total volume of waste water treated by public	34.94	40.16	36.60	41.04	40.46

treatment plants/Mm3					

Table 4. Solid waste landfilled at Mare Chicose/tonnes (Source: Statistics Mauritius 2016)

Waste type	2010	2011	2012	2013	2014
Domestic	402,816	389,743	365,867	408,858	401,785
Construction	2,394	5,306	5,601	6,141	2,363
Industrial	1,140	1,565	680	325	190
Textile	432	130	233	89	18
Tuna/Sludge	10,949	10,402	7,370	6,963	5,191
Poultry	6,339	5,942	6,061	5,316	5,707
Rubber tyres	481	447	372	315	431
Asbestos	44	15	6	50	26
Condemned goods	1,388	848	1,573	1,588	1,586
Difficult and hazardous	42	13	7	17	1
Paper waste	6	67	7	30	5
Others	1,771	65	149	243	175

Table 5. Greenhouses gases (GHG and Carbon dioxide emitted) (Source: Statistics Mauritius 2016)

	2010	2011	2012	2013	2014
Per capita GHG (total) - tonnes CO_2-eq/person	3.9	3.8	3.8	4	4.1

4. Port Louis in a nutshell

Port Louis is found on the North West side of the island and is bounded by sea and a mountain range for a total area of 46.7 km^2. As at 31st December 2015, there were 119,706 inhabitants in Port Louis which makes it the most densely populated district of the Island, boasting a staggering 2,563 P/km^2 (Statistics Mauritius 2016). Being the main administrative centre of the island, it comes with no surprise that Port Louis hosts the largest number of commuters coming for work from other districts (**Table 6**).

Table 6. Employed Population, Inflow and Outflow of workers, by district (Adapted from Statistics Mauritius, Census 2011)

District	Employed population commuting from another district (no.)
Port Louis	66,798
Pamplemousses	21,227
Riviere du Rempart	9,939
Flacq	7,169
Grand-Port	7,928
Savanne	4,779
Plaines Wilhems	43,326
Moka	21,684
Black River	18,717

4.1 Transport

Port Louis is a heavily dense area during the peak hours owing to traffic. The minister of public infrastructure shows concern about the actual state of transport in the capital city and claims that as at October 2015, there are about thirty four thousand vehicles that arrive in Port Louis on a daily basis. This figure is predicted to reach fifty thousand within a decade if the same state of affairs remains (Mauritius News 2015). The vast majority of vehicles entering Port Louis occur around eight to nine in the morning and it is estimated to be around eleven thousand which represent 43 % of all inbound traffic (Menon, 2004). Fowdur and Rughooputh (2012) estimated the cost of traffic congestion in Mauritius to amount to 0.1 billion US dollars per year. They further put into the lime light the large amount of greenhouse gases that such a situation entails contributing to 2.9 tons of net emitted carbon dioxide per capita. Such staggering figures show the growing importance of Port Louis and justify the need for proper policies to gear the capital city towards sustainability.

4.2 Water resources

Port Louis is supplied with 444 km of pipeline network, including twelve service reservoirs, serving around 48,661 subscribers (CWA 2014). Mauritius can boasts that 99.7% of the population has access to piped potable water in their houses (Munbauhal and Proag 2016). Eighty-six percent of population is supplied on an 18-24 hour basis during a normal season where the rainfall is within the average range for that season (CWA 2014). However, during dry season where the rainfall level is below the average range for that particular period, Port Louis is not supplied with water on a 24 hour basis. During these dry periods and owing to lesser access to water, residents of the capital city may feel less happy with this situation and hence, life in the city becomes a bit more tedious. However, as at 2015, 122.6 Mm^3 of water was sold compared to a production of 244.6 Mm^3 of water, this represent 50.1% of non-revenue water (NRW) which is water lost in the distribution network before reaching customers (Statistics Mauritius 2016). With proper policy and commitment from the Central Water Authority (CWA), the government and the private sector, water distribution could be greatly enhanced even during the dry seasons. One such project is already in place where there is a commitment to reduce non-revenue water from 45-50% to only 10% (CWA 2014).

4.3 Energy status

Energy generation in Mauritius remains principally oil based (94.3% as at end of year 2015) with very few coming out of renewable sources (5.7 % as at end of year 2015) (**Table 7**). The energy industries contribute 61.7 % of the total carbon dioxide emitted for the year 2014 (compiled from Statistics Mauritius, 2015). Being bounded by a mountain range and a sea, there is huge potential for Port Louis to achieve power independence by focusing on renewable energy like setting up of wind turbines on the mountain tops or even focus on ocean based energy generation like Ocean Thermal Energy Conversion (OTEC).

Table 7. Energy sources for Mauritius in 2015 (Adapted from Energy and Water Statistics, Statistics Mauritius, 2015)

Source of Energy	GWh	%
Hydro (Primary-Renewable energy)	121.9	4.1
Wind (Primary-Renewable energy)	2.7	0.1
Landfill gas (Primary-Renewable energy)	20.4	0.7
Photovoltaic Primary-(Primary-Renewable energy)	25.9	0.9
Bagasse (Secondary-Renewable energy)	509.8	17.0
Gas Turbine (kerosene) (Secondary-non renewable)	2.0	0.1
Fuel oil and Diesel (secondary-non renewable)	1,131.2	37.8
Coal (secondary-non renewable)	1,181.7	39.4

4.4 Waste management

On another standpoint, waste generated within the island has kept on increasing during the last decade. Waste segregation at source is still a myth and this explains the lack of composting being carried out at households and the low ratio of recycling being carried out in the island. Studies are in line with the need to have proper policy for waste management in a bid to achieve sustainability and this concept is at the heart of all cities due to their increasing population (Baud et al. 2001; Costi et al 2004; Jhingut 2016).

The actual status of waste management in Mauritius involves a linear model which starts with collection followed by transport to a treatment/processing plant and eventually disposal of the refuse, all showcased with monitoring and regulation (Jhingut 2016). The treatment/processing part of the solid waste management is in fact just compacting at transfer station before being disposed of at Mare Chicose landfill. This process cost around 1 billion rupees per year with about 70 % of that amount dedicated to collection and transport service (Jhingut 2016). Solid wastes collected from Port Louis and its suburbs are transported to Roche Bois transfer station at an average quantity of 6,308 tons per month with the majority of the wastes being organic (**Fig. 2**).

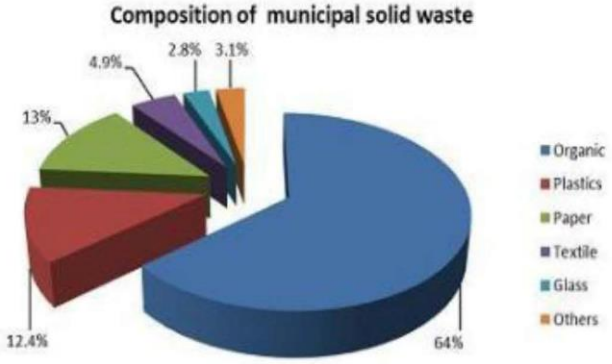

Fig. 2. Composition of solid municipal waste (Source: Ministry of Environment, sustainable development, and disaster and beach management)

Sixty percent of organic wastes represents a huge potential for composting while the 13 % and 12.4 % of paper and plastics hold the promise of potential recycling. If such endeavours are met, the waste generated and that would actually go to landfills will be about 10-15 % of the actual amount. Moreover, Jhingut (2016) points out that only 7% of solid wastes are diverted for recycling and composting. This provide room for future endeavours towards waste management. The actual status of Port Louis in terms of fluxes and dynamics of energy, water, transport and wastes management is far from being ideal and certainly do not reflect any aspects of sustainability. There is an urgent need to adopt sustainable attitudes and implement concrete policies in such a bid.

5. Proposed solutions

Indicators and annual goals are clearly laid out for assessing sustainability but there should be full scrutiny on metabolic flows within a city to address all the fundamentals of such a concept. Moreover, all the proposed solutions discussed below involve substantial financing and changes in policies within the right governance setup. This is where the main challenge lies and therefore, calls for further studies that will provide insights on how these hurdles could be circumvented.

5.1 Energy and air quality

The annual goals and indicator for Port Louis should be a decrease in amount of air pollutants including greenhouse gases emissions per capita, an increase in use of renewable sources of energy and reduce fleet average as preconized by Newman (1999). Mauritius has tremendous potential in developing renewable power sources such as wave power, ocean thermal energy conversion (OTEC), solar photovoltaic and wind power (Hammar et al 2012).Several cities in China, Japan, Taiwan and Singapore have made concrete steps towards implementing renewable energy usage policies with astounding success (Her 2008; Higgins 2013;Yoneda 2011; Matan and Newman 2016).

An approach towards energy sustainability for Port Louis could follow the similar path of Singapore with the concept of Zero Energy building. The concept is to retrofit existing building with solar energy generators. However, the cost of such an endeavour can be highly prohibitive (Harvey 2009) but potentially, the buildings can be 40% to 50 % more efficient than traditional ones (Matan and Newman 2016). Alternatively, wind turbines could be setup on the mountain tops surrounding Port Louis and the potential of the sea could be explored for power generation such as the Ocean Thermal Energy Conversion (OTEC) with the benefit of 24/7 all year round constant power generation with added benefit of no competition for input of land or other resources. One OTEC plant can prevent burning of 1.3 million of barrels of oil and prevent release of over 500,000 tons of carbon dioxide with an electricity production cost of 7Rs/kWh (Makai Ocean Engineering 2016). On a more substantiated approach, the African Development Bank (AfDB) has sanctioned funds for Mauritius to develop a Sea Water Air Conditioning system for buildings in Port Louis. Such a project will reduce carbon emissions by 40,000 tons annually and will entailed jobs creation directly such as engineers and technicians but also indirectly in fields including aquaculture, pharmacy and special water generation (Whitlock 2014). More resources, better job prospects will promote livability in Port Louis.

For residential areas in Port Louis, one approach is to promote energy saving attitudes through intensive sensitization campaigns. Rajkumarsingh and Goolaup (2012) posit that 40% of electricity savings can be achieved per households if old refrigerators are replaced by new ones, conventional incandescent lights are replaced by LED ones and old CRT televisions are replaced by LCD and LED ones. In this line of thought, the government can provide subsidies for purchase of new energy saving devices as recommended by Rajkumarsingh and Goolaup (2012), such an approach can result in an annual saving of 280 GWh of electricity.

5.2 Water

On a water perspective, there should be no shortage of water in Mauritius if the authorities implement recommendations of various master plans (Prayag 2014). Hence, the issue of water input should not be of great concern as water production covers water demands but there should be a drive for equity in its distribution to promote livability. The main challenge remains continuous supply of water even during the dry season. With ongoing projects such as the Singapore led taskforce aiming at decreasing non-revenue water to only 10% and with the setting up of the Bagatelle Dam, the water supply in Port Louis will be greatly improved during the dry season. Due to the proximity with the ocean, there can be a legitimate claim to resort to desalinisation of sea water to increase production of water; however, Prayag (2014) insists that such a process has too many negative impacts on the environment for it to be a viable option. Moreover, it is noteworthy to highlight that per capita water consumption in Mauritius is 168 litres per day (Statistics Mauritius 2016) as compared to 151 litres per day in Singapore (Singapore National Water Agency 2016). Such figures show that there need to be strong policies and sensitisation campaigns to promote more efficient use of water.

5.3 Waste management

Waste generated by Port Louis has a huge potential for composting and recycling. Jhingut (2016) proposes waste segregation at source but highlights the lack of sensitization campaigns on the matter. Recycling of plastics and paper might be a solution but Newman (1999) warns on the 'entropy' factor whereby using more energy and resources for recycling will not make it a viable solution. Composting seems to be valuable solution but this is dependent on segregation at source. A composting facility at La Chaumiere operated at only 61% of its capacity in 2014, hence showing the extra opportunities of such a step ahead. Alternatively, anaerobic digestion (AD) of organic fraction of municipal solid waste can decrease total waste disposed at Mare Chicose by 25 % with the added benefit of using the biogas liberated as a renewable source of energy. This will result in an annual decrease of 28,720 tons of carbon dioxide while the digestate of the AD can be used as compost (Susty and Venkannah 2011). Port Louis boasted a strong sewerage system but recent heavy rainfall resulted in lethal flashflood. Judicial enquiry in the matter attributed the floods to badly maintained drains, constructions on the drains and vegetation clogging of drains. This pushes forth the need to promote a vanguard upgrading of the system.

5.4 Urban Transportation

Port Louis being the main centre for trade and administrative buildings, it is quite apparent that it remains a hot spot for huge amount of automobile transit. Hayashi et al. (2004) links car dependency with improper land use and lack of alternative transport with consequential outcomes. To circumvent such drastic outcomes, there must be major change in transport policies. For instance, transport policies in sustainable cities aim at reducing the number of car usage within the city while promoting green mass transit and public transportation facilities (Gargett 2012; Goodwin and Van Dender 2013).

Singapore has developed an extremely efficient and vanguard system of metros and rail system complemented with efficient bus services and with a precisely tuned land use planning. Moreover, major Asian and European cities also rely on several types of rail-based systems (Newman and Kenworthy 2015). In the case of Mauritius, Ring Road, Mauritius Light Rail Transit (MLRT) and Bus Rapid Transit (BRT), which is basically an upgrading of the actual bus network, are three main projects proposed to alleviate congestion in Port Louis (Fowdur and Rughooputh 2012). On an ecological point of view and as a long term solution, LRT seems to be the most viable option (Fowdur and Rughooputh 2012). Furthermore, Menon (2004) proposes congestion pricing for peak hours and he backs his finding by claims of 16% and 44% reduction in traffic volumes in London and Singapore respectively by such an approach. Menon (2004) further claims a 10-15% reduction in traffic volumes for Port Louis. Such a drop in traffic will be reflected by an equal drop in emissions of GHG but further studies is needed to investigate whether there is a recrudescence of traffic volumes after the peak hours.

Moreover, dedicated areas for cycling and walking should be developed within a redesigned greener road networks for the city centre of Port Louis. Freights transiting through the Port should also have scheduled time frames to avoid unnecessary congestion and hence promote livability within the city.

6. CONCLUSION

The aim of the paper is to propose a theoretical application of Newman's Extended Metabolism Model in the city of Port Louis in terms of best practices in the field of energy, water, waste and transportation. The proposed solutions focus essentially on the need to rely more on renewable sources of energy and energy-efficient domestic appliances. Moreover, this study points out the need for equity in terms of water distribution in Port Louis which can only be achieved through better policy for water distribution while also highlighting the need for more efficient water usage. The best practice for waste is to focus on household waste segregation which will offer better prospects for recycling and composting. Eventually, the issue of congested traffic in the capital city can be alleviated through use of green mass transit and efficient public transport infrastructure. Each of the proposed solutions offers their own share of hurdles and challenges in terms of policy, governance and funding. Though the need for sustainability is essential for viability of coastal cities like Port Louis, there must be in

depth studies focussing primarily on the challenges and ways to mitigate them. Once these practices will be implemented, livability within the city will be enhanced. In fact, livability forms an integral part of Newman's Extended Model for Metabolism and is eventually the drive for urban sustainability. The key livability indicators are a decrease in infant mortality, transport fatalities and reported crime while favouring an increase in educational attainment, leisure opportunities and pedestrian-friendly spaces in the city. Such indicators can only be assessed for improvement when the proposed changes in the energy, water, waste and transport dimensions have been implemented.

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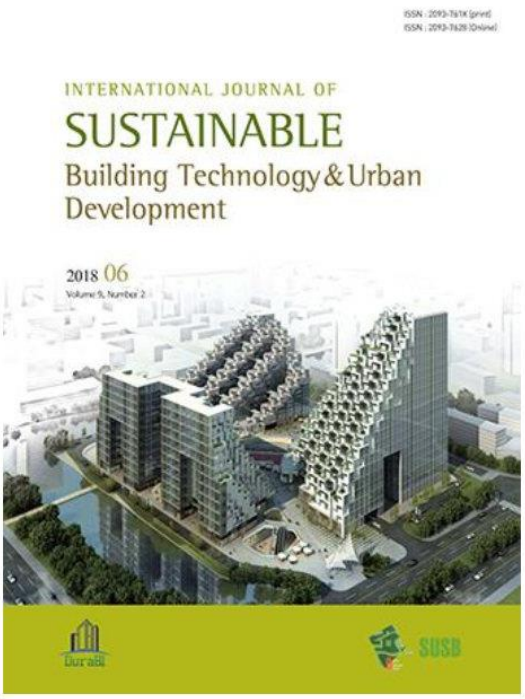

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The Zero-Waste City: Case study of port louis, mauritius

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ABSTRACT

Climate change is a global phenomenon that is expected to affect cities around the world to differing degrees and scales. Developing and emerging cities have a range of challenges to deal with in responding to climate change while aspiring to leap frog outdated approaches. It will be important for these cities to undertake well informed and strategic approaches to respond to climate change in urban planning; both in adaptation and mitigation. However, the two do not always complement each other and focusing on one area may be counterproductive overall. Literature also shows that it is also important to understand that adaptation and mitigation strategies in low income cities need to focus on social and economic issues along with environmental measures. This paper seeks to investigate how waste management can offer an extra dimension where urban policies can contribute to move towards a net-zero carbon city. Through a focus on waste minimisation there are a range of mitigation options available that are associated with reducing the wastage of energy, materials, and water. This paper outlines the findings of an assessment of technological, environmental, institutional and socio-economic opportunities and challenges related to a 'Zero Waste' pathway for one small emerging African city; Port Louis, the capital city of the island of Mauritius. The findings of this study seek to inform policy makers to implement 'Zero Waste' policies and approaches in Mauritius.

Keywords: sustainable development; zero-waste city; port louis; urban metabolism

Introduction

The Intergovernmental Panel on Climate Change [1] defines climate change as a term that encompasses any change in climate which could be attributed to natural causes or even human activity [1]. One prominent aspect of climate change is global warming [2], and it has been shown that greenhouse gases (GHG) emission is among the most important contributors of global warming [3]. Adaptation and mitigation strategies to climate change do not always complement each other on the road to sustainable development, hence leading to an imbalance in focus which can be counterproductive [4, 5]. Waste management is one such developmental aspect of emerging cities that have been posing a major hurdle towards sustainable development [6].

While Urban Regenerative measures are often tailored to planning and design, one aspect often lacks in sustainable urban design methodologies; material flows in regard to input and outputs [7]. showcases this in the Extended Metabolism Model, and underlines waste as a key dimension. Furthermore, the waste sector is a major contributor to global warming, with methane emission being the most important GHG [8]. These authors highlighted

that methane accounts for up to thirty-five times the potency of carbon dioxide as a greenhouse gas over a century.

Tackling this emission from waste will undoubtedly reduce the contribution of this dimension of a city for GHGs. Zaman and Lehmann [9] pointed out that managing waste in cities is among the most tedious issues that sustainable city designs must tackle. These authors further posited that the 'Zero Waste' concept can help to curb the impact of waste on GHG emissions. The "Zero waste" is defined as a systemic approach towards products and process design and managing whereby aiming at avoiding and eliminating waste generation [10]. Moreover, such a concept also promotes resources recovery and can help emerging cities design and implement proper policy for a 'zero waste' sustainable city [11]. Several factors affect the implementation of the 'Zero-Waste' concept in cities [12, 13].

This paper outlines the findings of an assessment of socio-economic, political/institutional and technological opportunities that are related to a 'Zero Waste' pathway for one small emerging African city; Port Louis, the capital city of the island of Mauritius. The findings of this study seek to inform policy makers to implement 'Zero Waste' policies and approaches in small emerging African cities.

Background

Concept of the zero-waste city

Rapid urbanisation and inexorable mass movement of people towards urban areas create an unsustainable setup. It is expected that by 2050 the world population will reach 9.5 billion with more than 66 % living in cities [14]. More people means more consumption, and this leads to generation of more wastes [15]. Worldbank [16] report on urban development highlighted that municipal solid waste (MSW) generated in 2010 was 1.3 billion tonnes per year and by 2050, this Figure is expected to reach 2.2 billion tonnes per year. Moreover, for the same time frame per capita waste generation rates will increase from 1.2 to 1.42 kg per person per day [16]. These rates vary greatly depending on the region and size of the cities (Table 1).

Table 1. Waste Generation Projections for 2025 by region (Source: [16])

Region	Current Available Data			Projections for 2025			
	Total Urban Population (millions)	Urban Waste Generation		Projected Population		Projected Urban Waste	
		Per Capita (kg/capita/day)	Total (tons/day)	Total Population (millions)	Urban Population (millions)	Per Capita (kg/capita/day)	Total (tons/day)
AFR	260	0.65	169,119	1,152	518	0.85	441,840
EAP	777	0.95	738,958	2,124	1,229	1.5	1,865,379
ECA	227	1.1	254,389	339	239	1.5	354,810
LCR	399	1.1	437,545	681	466	1.6	728,392
MENA	162	1.1	173,545	379	257	1.43	369,320
OECD	729	2.2	1,566,286	1,031	842	2.1	1,742,417
SAR	426	0.45	192,410	1,938	734	0.77	567,545
Total	2,980	1.2	3,532,252	7,644	4,285	1.4	6,069,703

Understanding how natural resources are being used at local level provides the most important scale for assessing resources management [17]. Such management of resources ensures that human population live within the limits of the region's supporting system in terms of social, economic and ecosystem level. This calls for a reliable and valid method to measure and assess sustainability frameworks [17]. Several methods of sustainability prevail in literature such as the ten indicators of the European Common indicators, the sixty-three indicators of the Global City Indicators Program and fifteen indicators for the Urban Metabolism Framework among others. One Indicator which caters for the Zero Waste City is the Finnish Sustainable Communities network (FISU) which promote members to cut on their emissions and consumption of natural resources.

However, Zaman and Lehmann [12] pointed out that it is very difficult to design sustainable cities, especially in the case of huge metropolitan areas. The same dilemma awaits emerging cities [18]. Nonetheless, there is still a window of opportunity to manage the relatively lower waste load generated and eventually pave the way towards a zero-waste city paradigm. The zero-waste city is one which minutely control all the pathways of goods from conception to collection of refuse in order to minimise waste load collected [13]. The term "zero waste" was first coined by Dr. P.Palmer in 1973 during his work on recovery of resources from chemicals [19]. Such a model of waste management involves a circular flow of materials as opposed to the conventional linear method (Figure 1) [19]. There is thus needing to shift from conventional waste management to a more rigorous waste control method which aims at eliminating all wastes from the city environment. The salient feature of the cyclical model of waste management lies in the fact that here the waste generated at the end of an urban metabolic process is used as the raw material in another urban metabolic process [20].

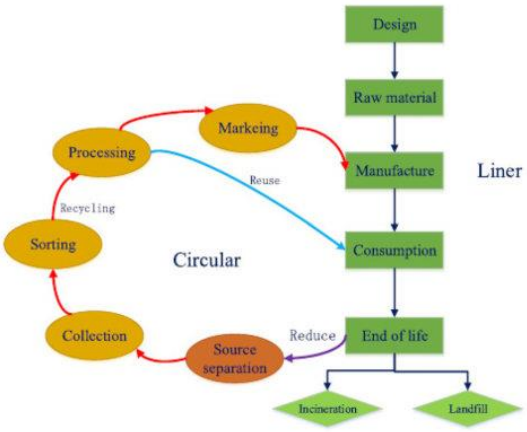

Figure 1. Linear and Cyclical resource flows (Source:[19]).

The Zero Waste management systems consist of several dimensions that are dynamic and interrelated [12]. These dimensions include the socio-economic attributes of the city, its political agendas, the environmental concerns and characteristics together with the technological attributes of the city (Figure 2). All these spheres consist of

dimensions that are associated with key drivers as described by [12] (Figure 3).

The social dimension of the Zero Waste City concerns consumption behaviour, while the economic aspect deals with cost-benefit aspect of engaging onto the zero-waste pathway. Political dimension involves policy and regulation in waste management while the technological dimension of the project concerns the efficiency and technology involved in waste management change. Moreover, the strategies to deal with any impacts fall under the environmental dimension [9].

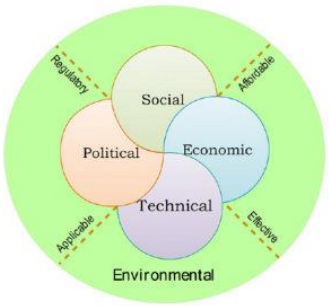

Figure 2. Spheres of the Zero Waste city (Source:[9]).

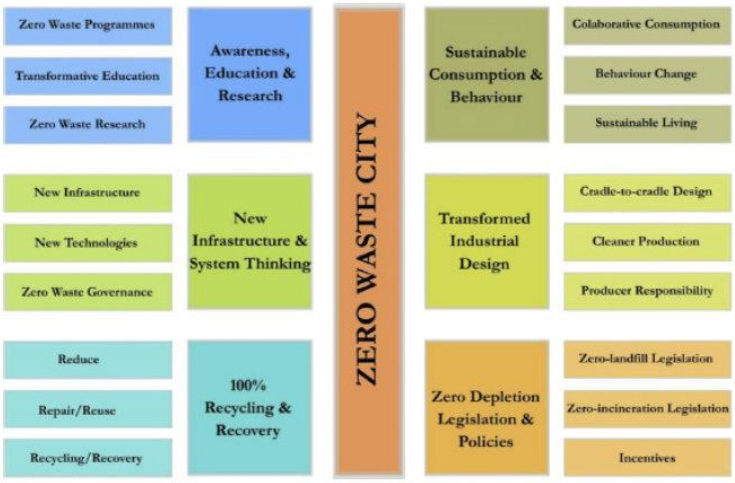

Figure 3. Drivers for transforming current cities into zero waste cities (Source:[12]).

Socio-economic and political dimensions

This dimension concerns sustainable consumption and behaviour. According to Zaman and Lehmann [12] such a dimension includes three indicators; i) collaborative consumption, ii) behaviour change and iii) sustainable living. Collaborative consumption offers a relatively new trend of socially enriched economy which not only contribute positively to sustainable development but also promote stronger community ties [21]. Examples of such

consumption pattern includes car-pooling and co-housing. [22] argued that collaborative consumption supplements the inadequacies of resource efficiency and technological innovations in reducing the use of natural resources. Business models aiming principally at consumerism is no longer an option. However, although there is a movement towards 'greening' supply chains as first step towards sustainable consumption, the surge in demands outpace 'greening' innovations [23]. This calls for a change in consumption behaviour from a consumerism dimension to a more sustainable approach [12, 23, 24].

Newman [25] brought into the limelight the concept of sustainable urban ecosystem as a self-renewing, self-regulating and zero waste city. Dizdaroglu [26] further extrapolated on the concept of sustainable ecosystem and postulated that sustainability depends on a '*balanced interaction between human activities and natural resources*'. This author further proposed key sustainable development principles to strengthen this balance. One such approach is through sustainable land use and urban design for enhanced liveability, introduction of green technologies to curb energy consumption, decrease GHG emissions through regulation of transport and to promote a greening of the environment. Another pathway focuses on effective environment protection policies through effective waste management [26].

This dimension on waste management focuses on the role of policy makers and financing institutions [18]. Weak institutional framework seems to be a major hurdle towards proper waste management in emerging and developing countries [18]. This dimension has key drivers in the form of policies for environment protection and waste management including public awareness [10, 27-29], cultural issues [18] and funding of waste management protocols [28, 30].

This dimension of zero waste city links to the cost benefit analysis and taxation of zero waste pathways [9]. Greyson [28] argued that the incremental approach by gradually reducing the impacts of an environmental issue is no longer an effective way of curbing the waste issue. This author warned about this concept being used by several cities and organisations and eventually leading to a lesser waste city instead of a zero waste one. Furthermore, he posited that the concept of zero waste city is being viewed as unachievable in the wake of current economic practices. For instance, economic growth is seen as having a negative impact on sustainability and when a city opts for sustainability approach, economic growth fails due to over-burdening of the system with regulations [28]. There is a need to review the economic system in place and make the pathway towards zero waste a plausible one.

Technological dimension

Singh et al. [31] posit that the concept of Zero Waste urges producers and consumers to move towards sustainable attitudes. These authors further stipulate that one approach towards tackling waste is through Zero Waste Manufacturing (ZWM). Through this concept novel technologies are being applied to promote recycling and reusability of wastes generated from other manufacturing processes. The importance of technologies as a focal point into a pathway towards zero waste has been highlighted by [29]. The author highlighted the need to implement new technologies in waste management systems to prevent loss of resources through thermal treatment

and landfilling. The technology dimension of the zero waste city concerns composting, anaerobic digestion and also incineration and landfilling [9]. Certain studies hail recycling as being an essential component towards effective waste management [32-35] while Leach et al. [36] point out that incineration or digestion technologies have lesser impact on the environment than recycling. Such contradictory findings promote further probe into effectiveness of technologies involve towards the zero-waste city. Another aspect that highlight the impact of electronics on the pathway towards a zero-waste paradigm is the concept of electronic waste. Overconsumption of electronics and shorter lifecycles of electronics leads to generation of substantial amount of electronic waste (E-waste) which has increased dramatically in recent years [37]. Such waste can lead to proliferation of toxic electrical and electronic waste which become more consequent for small cities [19]. However, there exist a market for good quality, second-hand electronic and electrical equipment in developing countries. This opens argument for exporting scrap electronic and electrical equipment to these countries [38].

Port Louis

Port Louis lies in the North West part of the island and extends over a total area of 46.7 km^2. It is bounded by the Indian Ocean and a mountain range. Port Louis is also a port city and the capital of Mauritius with a population of 149,194 [39]. This number soar during weekdays owing predominately to the large number of commuters that work in the city [40]. The City of Port Louis positions itself to welcome an urban regeneration [41]. Pathways of regeneration has been researched by Allam [42-44]where the author posits 3 key dimensions when smartly regenerating an existing city. Figure 4 highlights the dimensions of Metabolism, Culture, Governance as key components to smart a city.

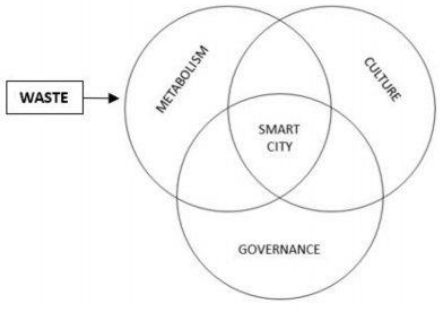

Figure 4. Smart Framework for Port Louis. Adapted from [42].

From a waste perspective, the waste dimension be a subset of the Metabolism dimension (Figure 4). It is to be noted that there is insignificant waste segregation at source and the amount of waste generated keeps on increasing every year. Waste management in Mauritius follows a linear model involving collection, transport to processing plant and eventually disposal at landfills [45]. This author also highlighted that 6,308 tonnes of municipal wastes

are collected monthly from Port Louis and transported to a transfer station before eventually being directed to landfills. The waste profile for Port Louis follows the same general trend for other cities with organic waste being the major chunk of collected garbage (Figure 5).

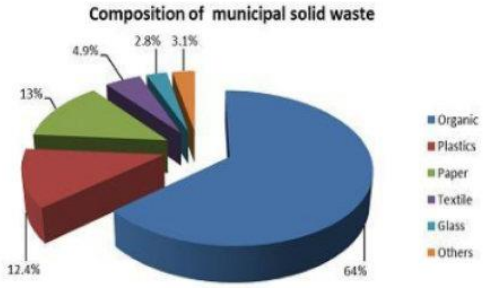

Figure 5. Composition of solid municipal waste of Port Louis (Source: Ministry of Environment, sustainable development, and disaster and beach management).

Waste as a Subset of Urban Metabolism

The Extended Metabolism Model [7] underlines, in Figure 6, the upgrading of the livability dimension within cities without compromising the resources for future generations. The concept of assigning a metabolic component to cities has first been coined by Wolman [46] which principally englobes the input of resources and managing the wastes generated with as little impact as possible on the city. Moreover, the model of viewing cities as biological entities has its origins within the work of Tjallingii [47] who draws lines of similitudes between cities and ecosystems. Newman's model strengthens upon these two dimensions but lays emphasis on upgrading livability and growth opportunities for the urban population.

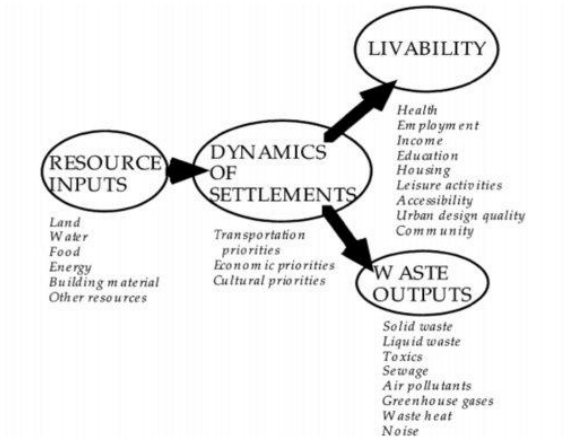

Figure. 6. The extended metabolism model of human settlements (Source:[7]).

The extended metabolism model has an inherent underlying principle that links inputs to outputs like any biological system. Resources that get in will eventually come out as waste products similar to the law of thermodynamics on conservation of energy. Decker [48] further extrapolate on the concept of cities metabolising raw materials with generations of wastes while a few years later Kennedy [49] defined the metabolic processes within cities as the summation of the technical, social and economic processes occurring within cities resulting in growth, energy production and waste elimination. However, Newman [7] underlies the factor of entropy in such a model in a sense that to manage waste generated, there needs to have further input of extra energy, but he also stresses on the fact that this defeats the purpose of sustainability. To circumvent the entropy factor, Newman [7] proposes a rigorous reduction in resources input.

One hallmark feature of Newman's model is that cities is entirely scrutinized as a biological entity with prime focus being upon human growth in terms of availability of opportunities [7]. Such a bold underlying principle lays the onus on livability, hence providing the nerve that links the environmental dimension of urban sustainability with that of economic and social dimensions.

Discussion

One principle component of the Zero Waste pathway is linked intricately to consumption behaviour of people [9, 12, 13]. According to the Ministry of Environment and Sustainable Development (MESD) (2013) Sustainable Consumption and Production (SCP) is a tool that can be used to promote more responsible consumption pattern. It is defined as a holistic approach that aims at curbing the detrimental impacts of uncontrolled consumption and production systems while laying emphasis on promoting quality living conditions. Such an approach focuses on efficient management of resources throughout product/service life cycle. From a waste management perspective, SCP promotes reuse and recycling of valuable resources within waste flow and is expected to:- i) upgrade quality of life without compromising on environmental integrity, ii) enhance economic growth through more responsible pattern of consumption, iii) focusing on greener life cycle of services and products and iv) preventing the 'rebound' effect whereby efficiency gains can be neutralised by a resurgence in consumption [50]. This approach from the Ministry shows that there is commitment at the highest administrative level to proceed towards a more responsible attitude for a Zero Waste pathway.

To put words into action, the Government of Mauritius introduced the Sustainable Public Procurement (SPP) which aims at making public expenditure more sustainable in terms of social, environmental and economic policies [50]. SPP has been introduced by United Nations Environment Programme (UNEP) in 2009 and in 2011, Mauritius joined in as a pilot country for implementing SPP policies. The focus is on seven products/services:- i) paper and printing, ii) IT devices, iii) cleaning products and services, iv) office and classroom furniture, v) vehicles, vi) food and catering services and vii) construction work. Port Louis being the main administrative centre of the island host the national assembly and the prime minister's office together with other ministries and public services such as hospital and social security services. These public departments are already gaining from SPP but this approach

could also be adopted by private companies as well as local authorities such as municipalities.

In fact, Walker and Jones [51] highlighted the robustness of a similar concept called Sustainable Supply Chain Management (SCM) in the private sector. According to these authors, SCP allows private companies to be more environment conscious. Incentives could be provided to such companies that are involved in SCM. In Mauritius, there are incentives for companies that want to set up smart cities. For instance, these companies are exempted from several financial burdens such as: i) income tax for a period of eight years, ii) land transfer tax and registration duty, iii) land conversion tax, iv) value added tax, v) customs duty and vi) 'morcellement' tax [52]. The same strategy could be adopted for companies that are involved in attitudes pertaining to zero waste pathway like waste segregation at source and SCM.

From an institutional perspective, the legal framework for waste management in Mauritius consists of the Environment Protection Act [53] and the Local Government Act (LGA). The former act was introduced in 2002 and amended in 2008 while the LGA was introduced in 2011. However, on a zero-waste pathway, there is need for further support through additional legal frameworks. One such example is the Zero Waste SA Act (2004) introduced in Australia which provide legal support so that people can upgrade their good practices in terms of recycling and waste elimination at home, work and industry [54]. One key aspect of this legislation was the complete ban of plastic shopping bags in a bid to avoid waste generation.

Atasu [37] proposed 'take-back' legislation to cope with E-waste. This practice involves activities which is linked to end of life management of electronics [37]. Two examples stand forth as torchbearer in dealing with E-waste; i) the Waste Electrical and Electronic Equipment (WEEE) directive as enacted by the European Union [37] and ii) the Specified Home Appliance Recycling (SHAR) introduced in Japan which lays the onus of recycling of electronic goods on the producers [55]. In Mauritius, there is no such legislative, but some good practices do exist. As at 2013, Mauritius imported an average of 20 million batteries annually while the mobile telephone devices amounted to 1.14 million. These Figures represent a potential danger of release of toxic chemicals in the ecosystem [50]. The Mauritius Telecom and several non-governmental organisation (NGOs) such as Mission Verte, BEM Ltd and Rotary Club of Port Louis initiated actions that promoted collection of used mobile phones and batteries. Boxes for collection are placed at strategic places including supermarkets, shops. Post offices together with public and private buildings throughout the Island. Once collected, these E-wastes are directed towards local and international recycling companies based on international regulations. Moreover, Rajesh [38] postulated that although E-waste can be seen as quite cumbersome for developed countries, there exist a market for scrap electronic and electrical waste in developing countries. This opens avenues for further studies in the possibility of Port Louis being a hub for recycling and exporting E-waste.

Municipalities are called to play the key role towards sustainable development on the zero-waste pathway [56]. Solid waste management (SWM) for Port Louis is under the direct control of municipality of Port Louis but is restricted to collection and transport to a transfer station. According to Jhingut [45], from the transfer station, the waste is then disposed of at Mare Chicose landfill. This author pointed out that Port Louis and its suburbs generate

an average of 6,308 tonnes of solid waste monthly with 64 % being of organic origin, 13% paper and 12.4% plastic wastes. However, only 7% of the collected waste are used for recycling and composting. Furthermore, as at 2014, a composting facility implemented at La Chaumiere was operating at only 61% of its capacity [45]. There is, thus, significant potential to extend this Figure to a much higher percentage. In a previous study Susty and Venkannah [57] proposed anaerobic digestion (AD) of the organic component of municipal waste. These authors postulate that such an approach will lead to a reduction by 25% of the total waste disposed at Mare Chicose while decreasing the annual carbon dioxide emission by 28,720 tonnes. Moreover, the biogas liberated can be used as a source of renewable energy while the digestate remaining still holds composting properties. Moreover, as recommended by Wiel et al. (2012), 'cradle to cradle' standpoint could be adopted by industries. This concept is a radical approach to sustainability in which products are recycled at the end of the lifecycles but without any loss in quality [58]. Port Louis being the only trade port of the island, it is the seat of many industries. Promoting the concept of 'cradle to cradle' through the right legal frameworks might be one aspect of taking industrial complexes on-board this endeavour of zero-waste.

It is essential that all stakeholders within the city take active part on the pathway towards sustainable waste management [59]. He identified twelve different stakeholders within the city ranging from NGO to political Figures and including the senior citizens and school children among others, where the findings highlighted the dimension of cooperation and civic responsibilities of each stakeholder towards adopting effective sustainable waste management attitudes. For instance, academia has the responsibility to infuse the paradigm shift towards a more responsible attitude in connection with consumption pattern and waste management while politician can include sustainable waste management in their agenda and push the same for municipalities. All these recommendations fit well with the need of Port Louis on a zero-waste pathway.

Recommendations for Port Louis

Based on the above discussion the following key recommendations are proposed for policy makers for the city of Port Louis:

1. Consolidate sustainable consumption practices for public and parastatal bodies.
2. Promote sustainable supply chain management in private companies.
3. Offer financial incentives such as tax exemptions for companies adopting zero waste practice.
4. Implement effective policy for dealing with E-waste in terms of collection, sorting, processing and exporting towards potential markets for such goods.
5. Promote sensitisation campaigns to promote attitudes and good practices like at source waste segregation.
6. Implement more effective waste segregation approach to maximise potential for recycling, recovering, anaerobic digestion and composting.
7. Maximise use of existing technologies and introduce new ones for better composting, anaerobic digestion and recycling/recovering of solid municipal wastes.

Conclusion

This study investigated key indicators in sustainable waste management from a socio-economic, political/ institutional and technological standpoint that might affect the potential application of a zero-waste concept in the city of Port Louis. Although several ongoing good practices have been noticed in terms of policies for coping with solid municipal waste, there is still room for further improvement. These improvements are in the form of a complete paradigm shift in connection with consumption patterns, further responsibilities on stakeholders, manufactures and suppliers of goods for the city of Port Louis, enhanced and more rigorous legislations pertaining directly to the zero-waste concept and an introduction of state of the art technologies for better 'cradle to cradle' management of solid municipal wastes. Moreover, as showcased by Allam [44] fiscal incentives could be introduced to encourage the private sector to take part in this endeavour, falling into the public domain. Logistics facilities for waste segregation at source must be setup to ensure maximisation of outputs through waste recovery, recycling, composting and anaerobic digestion. While this is a preliminary study of the incumbent issue of sustainable waste management through a zero-waste concept for one small emerging African city, there are highlighted avenues to explore to achieve this target. One limitation of this study is that the findings cannot be extrapolated to other emerging African cities because the 'one size fits all attitude' for sustainable development is not effective. This is because each city has its own socio-economic, political and technological dimensions. Moreover, as with all change, there is need to develop a proper framework to ensure viability and sustainability of such an approach for waste management, especially through in-depth cost-benefit analyses.

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Promoting resilience, liveability and sustainability through landscape architectural design: A conceptual framework for Port Louis, Mauritius; a Small Island Developing State

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Abstract

The world is witnessing an unprecedented acceleration in climate change. Enhanced global warming is disrupting climate patterns across the world leaving Small Island Developing States (SIDS) particularly at risk. Demographic patterns are changing and there is an inexorable movement of people from rural to urban areas across all countries of the world, including SIDS. While cities are therefore becoming denser, research and literature points concludes that few are sufficiently resilient to cater with changing climate patterns; an example is Port Louis, the capital city of Mauritius in the Indian Ocean.

In last 20 years, Port Louis has witnessed flash flood episodes that have claimed human lives. While upgrading has been undertaken to Port Louis' drainage systems as a response, the city is still heavily plagued by rainwater accumulation. Other cities in SIDS have also witnessed similar drastic events, and moreover face the dilemma of how to promote sustainable development while aspiring to pro-actively enhance the future liveability of their cities. Environmentally-responsive landscape architectural design offers the promise of renewing ties between people and nature. This paper examines this scenario, and proposes a conceptual framework to promote resilience, liveability and sustainability in the city of Port Louis through design. The paper explores principles, key dimensions and drivers of landscape architectural design and how they can be integrated within the existing structure and planning framework in Port Louis. The findings of this research, presented in this paper, contribute to addressing the dearth of literature and research on this topic pertinent to Port Louis and Mauritius, offering an exemplar for resilience and liveability scaffolding in cities of SIDS. This paper also offers policymakers and stakeholders with an extra dimension to consider for future urban development planning in SIDS cities.

Keywords: Small Island Developing States; Mauritius; Liveability; Sustainability; Biourbanism; Landscape architecture

1. Introduction

The world has entered a new urban era where the planet's ecology is being significantly influenced by human activities. A core agent is cities whom cause significant environmental impacts triggering a real need for eco-friendlier systems capable of scaffolding sustainability, liveability and resilience [1]. Although urbanization brings unique challenges, it is evidenced that other serious challenges and concerns arise. Improving the ecological

functioning and resilience of urban systems remains therefore central. As posited by Elmqvist *et al* [2], urban investments in ecosystem-based adaptation and green infrastructure can contribute positively to human and animal well-being and liveability in cities.

The city of Port Louis, the capital of Mauritius, recently witnessed flash flooding episodes and has been plagued by rainwater accumulation and ponding. This environmental pattern is increasingly commonplace in all Small Island Developing States (SIDS) [3], which are vulnerable due to their lack of preparation and logistics to deal with such situations.

SIDS were first recognized as a distinct group of developing nations at the United Nations' *Conference on Environment and Development* in June 1992 [4]. The *Barbados Programme of Action* was adopted in 1994 to assist the SIDS in their sustainable development efforts [5].

For Mauritius, enhancing sustainable development and enhancing future liveability in its cities is therefore a primary concern.

Figure 1: Location of Mauritius. Source: http://ontheworldmap.com/mauritius/mauritius-location-on-the-indian-ocean-map.html, accessed 1 March 2018.

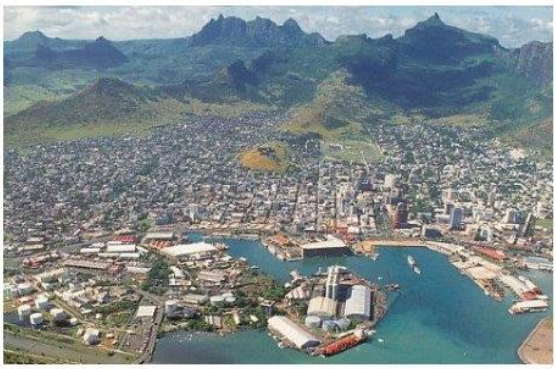

Figure 2: Port Louis, Mauritius. Source: https://ports.co.za/portlouis.php, accessed 1 March 2018.

Figure 3: Flooding in Port Louis, Mauritius in 2013. Source: https://emmaozsen.wordpress.com/2013/04/01/482/, accessed 1 March 2018.

Urban ecology evolved internationally in the 20th century as being a potential solution for improving sustainability and liveability in cities [6]. Authors like Steiner [7] and Ndubisi [8] have asserted that ecologically motivated landscape architecture and site design, such as the Sustainable Sites Initiative [9], is good practice.

Port Louis has attempted to respond to this theory by seeking to enhance sustainability and reduce flood concerns through contemporary design and landscape management mechanisms and initiatives. The flood episode of 2013, being one major effect of climate change experienced by Mauritius so far, demonstrated the urgent need to address sustainability, liveability and resilience nationally.

2. Background

When Mauritius was first colonised by the Dutch between 1638-1710 they established a harbour at the southern village they named 'Grand Port'. Urban planning for Port Louis, the capital city of Mauritius was led under French colonisation from 1715-1810, and then under the British until independence in 1968. The French approach was to favour large alleyways and to maintain a lush canopy. Their designed infrastructure satisfactorily sustained the Port Louis population of around 6,779 inhabitants in 1968. However, today Port Louis accommodates a population of 155,226 being a demographic increase of 2,290%. The city witnessed this exponential increase in population without expanding its basic infrastructure services. Coupled with the effects of climate change, sandwiched between the Signaux Mountains and the Indian Ocean, this rapid urbanisation has brought forth numerous concerns in terms of city planning. Key climate change risks and impacts for Mauritius are summarised in Table 1 of which Port Louis is located in the Marine ecosystem type (as seen in Figure 5) wherein all impact factors are pertinent.

Ecosystem types	**Climate change-related impacts**				
	Sea level rise	Acidification	Extreme weather events	Invasive species	Anthropogenic pressure
Forest plantations		✓	✓	✓	✓
Natural Forests			✓	✓	✓
Agriculture ecosystems – Grassland			✓		✓
Agriculture ecosystems – Cropland					✓
Wetlands	✓			✓	✓
Marine (fisheries, mangroves, and coral reefs)	✓	✓	✓	✓	✓
Islets	✓		✓	✓	✓

Table 1: The main climate change-related impacts on the main ecosystem types in Mauritius. Source: [10].

The contemporary post-independence government response to Port Louis' urban planning has been haphazard with little comprehension of the historical drain and creek system in the city and their capacity to handle the huge volume of runoff because of the major urbanisation adoption of non-porous surfaces.

With urban sprawl, there has been a rapid reduction of the French-stablished green areas in the city. Today it is showcased by the PORLWI Collectif that Port Louis encompasses around only 16m^2 of green space per capita, a figure well under the 35m^2 as recommended by international standards [11].

Green space loss in favour of built fabric expansion has brought forth numerous issues specific to Port Louis including:

- an increase in the urban heat island effect that is also affecting Port Louis' economic footprint [12];
- a reduction in air quality [13];
- a reduction in physical and accessible public open space; and
- a reduction in the natural rain water absorption potential contributing significantly towards flash flooding [14].

3. Resilience

With rapid urbanisation in Mauritius, urbanization has amplified the sealing of the drainage basins and conventional engineering work in river valleys (eg. riverbed straightening and narrowing) there increasing the threat of urban floods throughout Mauritius [15], as seen in Figure 4. Port Louis particularly experienced this situation in 2013, as seen in Figure 3. The 21st century has witnessed augmented flood threats due to global climate change with intensified urbanization and extreme weather events [15]. Majewski [16] has argued that extreme meteorological and hydrological events are increasing in frequency. However, the manner in which cities and towns have planned, used and developed land is also another cause exposing populations to coastal and river flood risks.

The European Union Floods Directive (2009), introduced alongside a requirement of integrating flood risk management and hence the coexistence with water, is one of the preferred approaches. Some of these measures include the implementation of:

- flood protection efforts;
- sustainable rainwater harvest approaches; and
- application of underground and surface water management in drainage basins.

Majewski [16] has claimed that other measures should include:

- warning systems and hydrological and meteorological prediction;
- educating how to decrease risk of property damage in flood-prone areas; and,
- evacuation and protection plans.

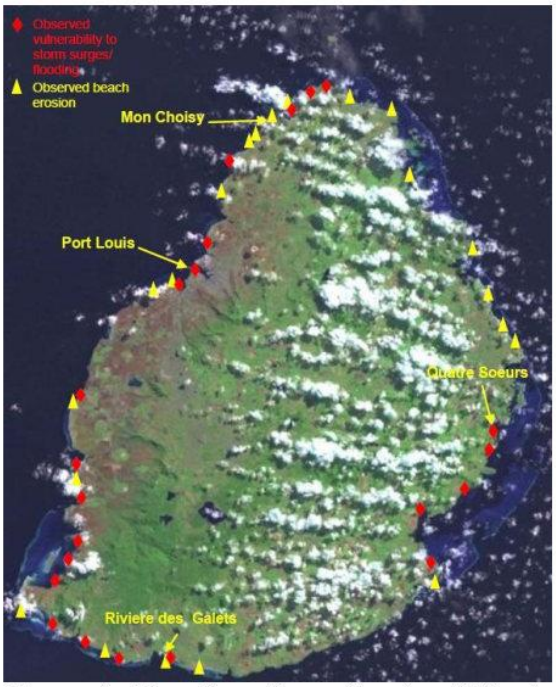

Figure 4: Mauritius observed vulnerability to flooding and beach erosion. Source: United Nations Development Programme - Mauritius (UNDP Mauritius), https://www.preventionweb.net/english/professional/maps/v.php?id=32259, accessed 1 March 2018.

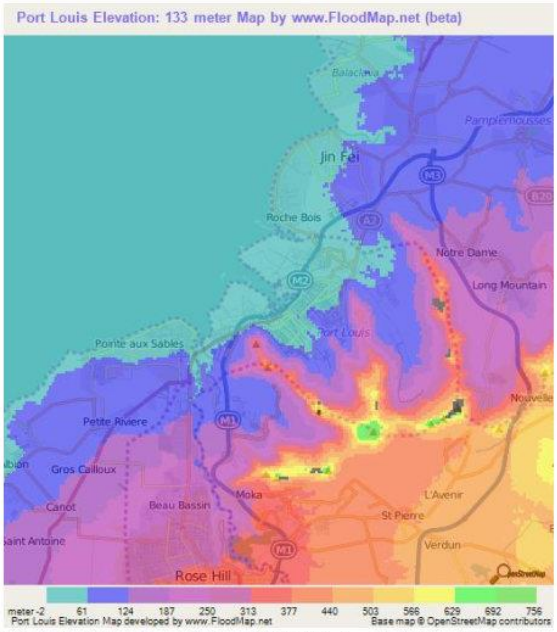

Figure 5: Elevation of Port Louis, Mauritius, by www.FloodMap.net. Source: http://www.floodmap.net/Elevation/ElevationMap/?gi=934154, accessed 1 March 2018.

4. Liveability

The separation of city and nature was previously a predominant characteristic of urban architectural designs [17]. This philosophical approach is hazardous and costly because it disregards a city's natural processes and separates human living from nature. Allam [14] and Grant et al [18] argue that the more the disconnected humans are from nature the more individuals do not understand the link between healthy cities and healthy ecosystems. Today, it is acknowledged by scholars that landscapes associated with infrastructure and buildings can accommodate multi-functional layers of vegetation and soil controlling surface water, providing wildlife habitat and food,

and keeping the city cool as contrast to its long-perceived ornamental and Gardenesque values [18]. Grant [18] further argues for the need for panoramic, trans-disciplinary thinking and co-ordinated action to enable a grey-to-green transformation of cities, to enhance the liveability of these places to its citizens.

Numerous researchers are increasingly trialling new methods to analyse cities to assess and measure their liveability [19]. However, it remains difficult to define 'liveability'. While some researchers' claim that liveability is tied intrinsically to physical amenities such as green space and parks, others supports its connectivity to economic dynamism, career opportunities, cultural offerings and human safety for a family to co-habitat in. However, the most important conclusion is that liveability is connected to infrastructure and sustainability issues [19].

The decision of forming a balanced relationship between the city and nature is crucial.

5. Sustainability and Maintainable Solutions

Because of the larger flood threats in the European Union, the member states have responded in implementing strategic programs and such should also be the case in Port Louis. For instance, the programs of Making Space for Water (2005) in the United Kingdom, and Room for the Rivers (2006) in The Netherlands, seek to increase river valley retention capacity as well as improving drainage basins together with enhanced co-ordination of spatial planning and flood protection. These strategies emphasise integrating sustainable water management and urban planning in areas far from simply the riverbanks (improved rainwater retention for decreasing flood threats) and urban waterfront zones (which offers direct protection from floods).

Three primary trends currently dominate management of urban waterside areas which include [20]: riverbank urbanization and urban revitalization of downtown waterside areas; sustainable land management allowing enhanced retention capacity and using construction forms which adapt to changing water levels; and, environmental revitalization of river valleys.

Table 2 offers a synthesis of key ecological design strategies that could be applied in Port Louis to better negate climate change risks and threats as well as increasing the urban liveability and built environment quality of this rapidly growing urban landscape.

Principle	Aspects
Climate and context	City's climate conditions, density, landscape, available resources
Renewable energy	Development of renewable energy source, energy efficiency planning, cogeneration, intelligent building management
Zero-waste	Reduce, reuse, recycle
Water	Reduce consumption, efficiency of use, water quality, underground

	water catchment area, storm water retention and flood management, rainwater harvesting, local treatment of waste-water, integrated urban water cycle planning, water management during drought
Landscape and urban biodiversity	Local biodiversity, wildlife rehabilitation, forest conservation, urban vegetation, inner city gardens and urban agriculture to counteract UHI effect, tree planting, restoring stream and river banks, de-pavements and rehabilitation of canals
Sustainable transport and good public space	Easy access to green public transport, promotion of bicycle use and safe bicycle alleys ways, smart vehicles, walkable city
Density and retrofitting	Densification of the city, retrofitting inefficient building, better land use planning, public space upgrading
Passive design for buildings and districts	Low energy, zero-emission design, reduce energy use, compact solar architecture, bioclimatic architecture, solar architecture, energy generating buildings
Liveability and mixed use	Affordable housing, healthy community, social inclusion, flexible housing typologies, diversity, integrating a diversity of economic and cultural activities,
Local food and short supply chains	Local food production, regional supply, urban farming and agriculture, allotment gardens, roof gardens, urban market garden, paper bags, recycling
Identity and sense of place	Public health, cultural identity, urban heritage, air quality, grassroots strategies, creativity of government and citizens, health, activities and safety
Urban governance and leadership	Evolutionary and adaptive policies, participative decision making, and responsibility shared with empowered citizenry, enabling citizens, updating building codes, improve planning, legislating controls on density and urban sprawl, certify urban development projects
Education, research and knowledge	Knowledge and capacity development, scholarships for areas relating to sustainable urban development
Resilience	Provide for free first aid courses, training for support team to the fire brigade, communicate all emergency measures to the citizens and carry city wide rehearsals on exceptional situations

Table 2: Key Ecological Design strategies pertinent for Port Louis, Mauritius. Source: adapted by the authors from [21].

5.1 Planning guidelines and regulations in Port Louis

While there are numerous documents outlining parameters for urban development in Port Louis, the enforcement of guidelines remains a local challenge. The contradictory nature, or difficulty of clear interpretation, of planning codes across various planning documents further accentuates this issue.

This creates a leeway for haphazard development, and provides opportunities for developers to maximise their land use for increased economic profitability while disregarding the development's impact on

their immediate surrounding. Allam [22] confirms that there is a mismatch between planning documents and the demographic boom of 330% in the last century.

The confusing guidelines coupled with a lack of guidelines enforcement has enabled approval of various projects that contributed to the flash floods of March 2013; namely the construction of buildings on classified rivers and streams; the KFC building, Air Mauritius Parking, Rogers Parking, Garden Tower and Hawkers Palace [23]. Those developments however do not abide by the Mauritian *Forests and Rivers Act 1984* river buffer requirements [24]. Figure 6 illustrates development along the Ruisseau du Pouce Stream where the capacity of drains has been reduced.

Figure 6: The Hawkers Palace at Ruisseau du Rouce. Photo by author (Allam, 2018)

6. Landscape Architecture and Ecosystem Functions

Five principles of ecosystem functions include recognition that: urban areas or cities are ecosystems; cities or urban areas are heterogeneous; cities or urban areas are dynamic; cities or urban area biophysical and human components interact; and, biophysical processes are crucial in them [25].

The first principle provides the basic theory of contemporary urban ecology. It indicates what needs to be included for explicitly addressing urban systems. The urban ecosystem concept embraces the deepest urbanization levels and the addresses the function and structure of exurban fringe [25]. The other principles relate to the specific implications of the first principle. Hence, the first principle has been discussed in this paper.

6.1 Cities are Ecosystems

Cities and urban areas are ecosystems as they have interacting physical and biological complexes. Therefore, one should not consider that ecosystems are stringently homeostatic, self-maintaining and fundamentally closed entities [26]. These assumptions are not invoked by the definition of core ecosystem. In simple terms, an ecosystem relates to the interaction between a physical complex and a biotic complex [27]. This definition remains the core motivating contemporary research and application by Jax [28].

Cities contain organisms, people and light, water, soil, air and physical regulators as day length and temperature. Biotic complex are also present in cities which have complex social structures [29] and these include institutions [7]. Machlis et al. [30] claim that the sumptuousness of social interactions and structures are the heart of

the inclusive conception which they refer to as the 'human ecosystem framework'. In the same vein, a cities' physical complex is not only made up of native soils and substrates and existing or emerging non-managed animal populations and vegetation, but contains covered or highly modified soils, introduced or maintained vegetation, paved surfaces, utility infrastructure, roads and buildings as well. Hence, in contrast to agricultural or wild ecosystems, the urban ecosystem has additional complexities [31].

The precise scenery of the novel structures contributing to the biotic and physical complexes in a city may be perceived as conservatories to the concept of basic ecosystem [27], rather than violations to the definition [32]. Because urban ecosystems comprise new human artefacts such as infrastructure and buildings and new land forms, an additional complexity layer is emphasised as the 'built' component. Therefore, cities are human ecosystems with built, physical, social and biotic components that interact with one another ([33; 34]. Any spatial arena containing interacting biotic and physical complexes is an ecosystem. In addition, smaller ecosystems may be found in larger ecosystems and this remains important in the application of ecological insights in landscape design [7].

6.2 Implications for Ecological Design

The interactions of the built environment, social structures, physical conditions and setting and organisations happen through information flows, organisms, energy and matter [25].

Van der Ryn and Cowan [35] define ecological design as 'any form of design which reduces the environmentally destructive impacts by integrating itself with living processes'. It assists in connecting the scattered efforts in ecological restoration, ecological engineering, sustainable agriculture and green architecture and other fields. Urban design, technologies, buildings, transportation system and land uses are some of the reasons that give rise to ecological problems. Ecological design should be able to understand patterns which connect to nature and hence it remains important to work outside mainstream disciplines for seeing matters in larger contexts. Landscape architects need to foster integration between urban ecosystems and designs to save scarce resources for future generations [2].

Malaysian architect Ken Yeang [36], argues that there is a need to: apply ecomimesis being designing by imitating ecosystems; include environmental bio-integration; imitate the functions, structure, and processes of nature as in their ecosystem; not misled by technology; not assuming that if a building yields a high rating in green-system rating it is successful; and, recognizing that ecosystems contain both abiotic and biotic constituents acting in the biosphere.

These principles help in creating a sustainable city by reducing waste, creating healthy social relationships, decreasing noise pollution, increasing accessible open green spaces, enabling healthy and greener buildings, decreasing indoor and outdoor pollution, ensuring fewer toxic

transmissions, and increasing energy efficiency [36].

7. Potential Solutions

7.1 Urbanization of riverbanks and urban revitalization

The main argument for revitalization was that areas had become a barrier separating cities and towns (humans) from water spaces as well as negating visual and emotional access to rivers in providing breathing space in swarming cities. Januchta-Szostak [37] have highlighted that successful revitalization projects in port districts demonstrate the social and landscape potential of riverside regions. The primary aim of urban waterfront transformation was to reintegrate riverbanks with the urban fabric (with respect to their function and composition) and scaffolding investment zones with outstanding landscape attributes. The sudden rise and interest in waterside parks, squares and boulevards being a showcase for cities and towns prompted a need to invest in active flood protection systems in profoundly built-up downtown zones that could be turned into attractive areas for residential and recreational integration, such as London's Thames Barrier Park [30].

7.2 Construction attuned with the changing water levels

The necessitation of new types of flood-proof land management and construction techniques and practices to allow infiltration of flood water has been acknowledged as enabling the need for ensuring space for increasing flood water and inevitable expansion of cities [38]. There is a need to establish safe evacuation routes while considering the dynamics of rising waters. In addition, the need for quality zoning to enable adaptation to the rising water and intensity and direction of flood water flow based on planning of flood risk maps that would simultaneously allow shaping landscape architectural designs closely with water [20]

Pilot projects, such as in Littlehampton and Peterborough in the UK, demonstrate innovative rainwater management systems in urban areas enabling flood protection as part of Long-Term Initiatives for Flood-risk Environments (LIFE) initiatives [38]. In these cases, flood risk maps were the foundation for new urbanized shaping approaches enabling periodic floods mitigating and acceptance of the need to enable natural environmental processes and engineering.

7.3 Urban rainwater management

The key to preventing urban floods is to reduce surface runoff since its volume increases considerably when large urban surface areas are sealed. The USA and several EU member states have recommended adoption of the Sustainable Urban Drainage Systems (SUDS) that mimics environmental processes that occur naturally including infiltration, detention and retention [39]. These Systems help to decrease pollution levels and rainwater runoff from the urbanized zones.

Rainwater management in SUDS may be classified into 3 stages [20]: collecting and transporting water; water distribution and retention for reuse; and, evaporation and

infiltration. SUDS stages stress the purification of rainwater runoff via natural properties of the vegetation and ground. Thus, water needs to be clean in any composition so as to be socially and visually attractive [20]. Therefore, there is no need to conceal purification processes from the public. Moreover, the water-plant ecosystem serves as a recreational purpose and help in ecological education of the inhabitants [40].

7.4 Recommendations to local planning guidelines

Based on the review of current guidelines and regulations in Mauritius, it is noticed that guidelines are outdated, and addendums do not cater for environmental impacts of climate change. For example, the *Design Guidance Policy*, part of the *Mauritius Planning Policy Guidance 1* [41], is more than 14 years old. It is also recommended that guidelines are designed in a more contextual fashion for both Urban and Rural areas. The *Planning Policy Guidelines 6* [42], does this well by imposing strong regulations on Heritage. This needs to be expanded outlining desired activities, development and regulations at street block level. Further, there is the strong need for enforcement of urban guidelines and regulations. Numerous bodies across various Mauritius ministries currently issue clearances, which work in conflict from each other. There is a need for a centralized committee at municipal level for the review of all developments prior to the issuance of development permits at municipal level.

8 Conclusion

This papers explored sustainability and liveability through the five principles of the ecosystem. The first principle which showcased urban areas as ecosystems and the implications for ecological design were emphasized. This was particularly important for Mauritius, as being part of the SIDS which hosts a unique fragile ecosystem.

The need for a resilient fabric was emphasized due to the local challenges of Port Louis through the advent of climate change; and its impacts on weather patterns. The issue of flash floods which impacts on both economy and society were discussed and solutions were offered that tallies with ecological and sustainable methodologies.

Urban planning policies and guidelines relating to Port Louis was reviewed and recommendations were made to decrease the risk of flash floods. It was further argued that urban 'green and blue infrastructure' could play a fundamental role in enhancing the adaptive capacity of coping with climate change [2].

Altogether, the proposed recommendations are aimed to ensure that appropriate policy anchors into governance and practice to ensure urban densification to prevent urban sprawl; conserve and enhance nature; ensure proper planning for climate change mitigation; and, support a more efficient policy for urban disaster management.

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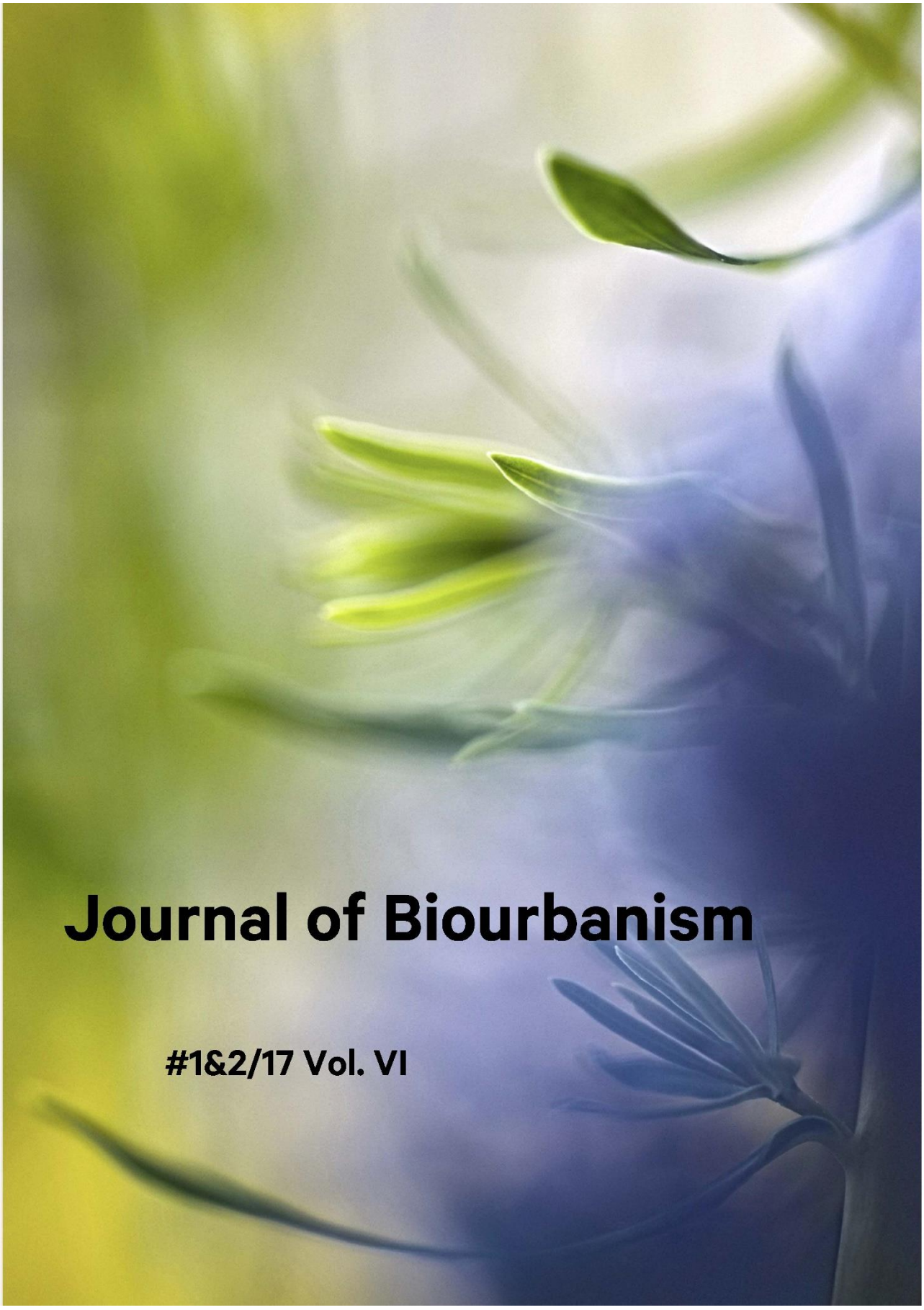
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Building a Conceptual Framework for Smarting an Existing City in Mauritius: The Case of Port Louis

Zaheer Allam

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ABSTRACT

Sustainable urban transformation, promotion of green economy, and investment in better urban living facilities seem to lack a connecting nerve fiber within this digital era. Smart cities offer such a connecting framework that links technology, human capital, community infrastructure, and governance in a bid to promote sustainability and ensure viability of cities. Such a relatively novel approach to urban development offers promise of enhanced performance and increased productivity within a sustainable milieu. The capital city of Mauritius has a valid framework for becoming "smart". This study aims at proposing a conceptual framework for smarting the city of Port Louis, which is the main administrative center and harboring the only trade port of the island. The viability and sustainability of such an undertaking will be pondered upon. The findings of this study aim at paving the way for the main stakeholders in urban development towards ensuring sustainable urban transformation of Mauritius using a smart conceptual framework.

Keywords: sustainable, urban, smart cities, existing city, Port Louis

INTRODUCTION

The 21st century human being is principally an urban dweller as confirmed by the inexorable movement towards metropolitan areas in a quest for better living opportunities. It is predicted that within the next 35 years, 66% of world population will be living in cities. Such a situation will add up drastically to the actual 80% of total carbon dioxide emissions of urban origin, while wanting more inputs in terms of water, energy, and raw materials (Wu, 2010). There is a common cognizance globally towards promoting a culture of sustainable urban development, which will ensure sound economic growth without jeopardizing resources for future generations. The prime dimensions of focus towards sustainability have been predominantly aimed at i) social, ii) environmental, and iii) economic indicators of cities (Klang, Vikman, & Brattebø, 2003; Maclaren, 1996; Moussiopoulos, Achillas, Vlachokostas, Spyridi, & Nikolaou, 2010; Spangenberg, 2002). However, there seems to lack an apparent connecting nerve that allows all these dimensions to really boost the urban sustainability movement forward.

In this digitally connected era, Information and Communication Technologies (ICT) can offer such a bridging component in the urban sustainability mix that eventually paves the way for the concept of smart cities (Deakin & Allwinkle, 2007; Paskaleva, 2009). Guidelines have already been laid out for promoters to invest into creation of new smart cities from the ground up with various economic incentives coupled with a Smart City Certificate (SCC) for the developers (BOI, 2016). This concrete commitment towards promoting Mauritius as an ecologically friendly and technologically advanced smart nation has been further substantiated by the issue of the first Smart City Certificate to Omnicane Ltd. for its smart city project at Mon Trèsor, in the Southeast of the island. Despite this being a bold statement of commitment, there is no such course of action for smarting current cities such as Port Louis. Such a gap in literature and policy to tackle existing unsustainable cities and propose ways to smart them out has been vehemently brought forth by Kitchin (2014a).

The capital city of Mauritius hosts the only trade port of the island and is the main administrative center. Port Louis is infamously renowned for its traffic jams during peak hours and relatively lack of green spaces and pedestrian friendly areas (Guttee, 2015). Another issue that holds a central position of Smart Cities is efficient waste management (Zanella et al., 2014). However, Port Louis generates 6,308 tonnes of municipal solid waste monthly with the majority being of organic origin (Jhingut, 2016). This Author also highlights that there is no waste segregation at source and waste management through recycling, composting or anaerobic digests is inefficient. Zanella et al. (2014) postulate that through a smart city setup and in-depth use of ICT, waste management will be optimized resulting in significant savings and ecological advantages. Such profile of the capital city of Mauritius offers much room for promoting a smarting up of existing setups.

This paper therefore aims at proposing a framework for smarting the city of Port Louis based on models used in other cities but by trying to circumvent the one-size-fits-all policy. The dimensions identified in the framework will provide policy makers with groundworks to build upon.

BACKGROUND

The capital city of Mauritius, Port Louis

Located in the Northwesterly side of the island and bordered by the Indian Ocean and a mountain range, Port Louis is a bustling city of 119,706 inhabitants living in 46.7 km^2. This makes it the densest urban area of the island.

Moreover, the capital city hosts the only trade port of the island and is the main administrative center as seen by the prominent presence of ministerial buildings, businesses, and head banking offices. This explains the large number of commuters that travel towards Port Louis on a daily basis (Table 1).

District	No. Employed Commuter Population
Port Louis	66,798
Pamplemousses	21,227
Rivière du Rempart	9,939
Flacq	7,169
Grand-Port	7,928
Savanne	4,779
Plaines Wilhems	43,326
Moka	21,684
Black River	18,717

Table 1. Employed population, inflow and outflow of workers by district.
Census 2011 adapted from (Statistics Mauritius, n.d.) (Table sourced by the Author).

Such a large number of inbound travelers create a heavily congested area during peak hours that Fowdur & Rughooputh (2012) estimate at a cost of 0.1 billion USD per year, entailing 2.9 tons of net emitted carbon dioxide per capita. This drags Port Louis far away from sustainability concepts in terms of urban transportation. Moreover, it should be noted that Mauritius currently shows only a 20% energy self-sufficiency with oil still being the major energy source of the island (Koodaruth et al., 2017). With respect to water resources in Mauritius, Prayag (n.d.) stresses the need to implement recommendations from major water dimension studies to avoid shortages. This is backed by reports from the Central Water Authority of Mauritius, which highlight a 50.1% non-revenue water getting lost within the system. Another dimension of Port Louis that is of concern is municipal wastes. Solid wastes collected from Port Louis and its suburbs are transported to a nearby transfer station at an average quantity of 6,308 tons per month with the majority of the wastes being organic (Figure 1). Sixty percent of organic wastes represents a huge potential for composting, while 13% and 12.4% of paper and plastics hold the promise of potential recycling. If such aims are achieved, the waste generated that would actually go into landfills will be about 10–15% of the actual amount. Jhingut (2016) points out that only 7% of solid wastes are actually diverted for recycling and composting.

Beyond energy, water, and waste issues, there is an apparent inability for Port Louis to deal with heavy precipitation, which eventually trickles down into flash floods that have already claimed human lives (Khedo, 2013).

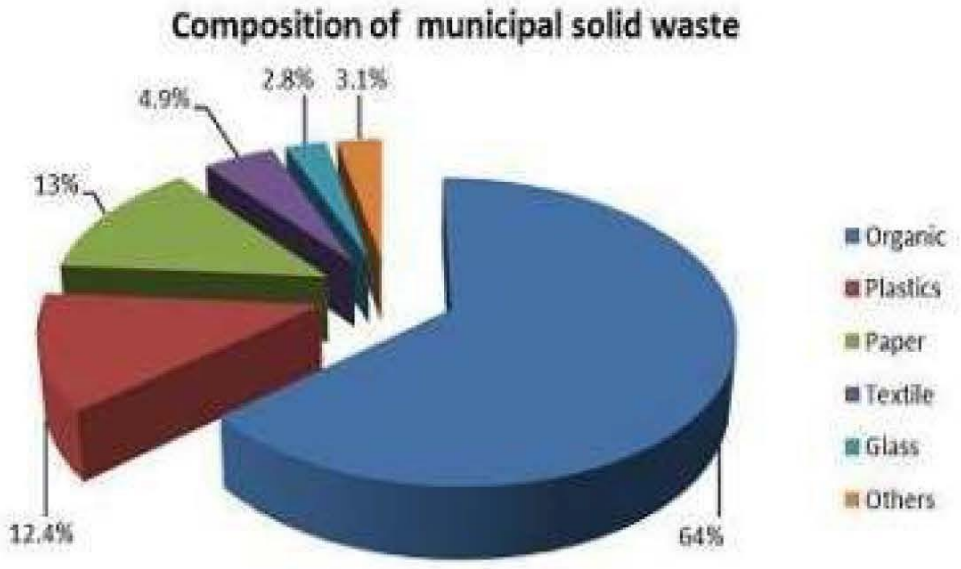

Figure 1. Composition of solid municipal waste, from the Ministry of Environment on sustainable development, disaster, and beach management (Image sourced by the Author).

From a people's perspective, culture is a driving force for sustainability as depicted by number 11 of the United Nations Sustainable Development Goals (Norström et al., 2014). However, despite Mauritius is an acclaimed melting pot of cultures, the capital city fails blatantly to exploit such a powerful driver for sustainability. Culture is a factor that adds vibrancy and life to a city, yet the lack of prominent green spaces and dedicated pedestrian areas, coupled with traffic jams and a noisy atmosphere, prevents any spirit of enhanced livability and hinders the right sustainable attitude (Guttee, 2015).

The island has reliable Internet connectivity from major service providers. For instance, as of March 2017, Mauritius had an Internet connectivity rate of 62.7% of the overall population, which makes it fourth on the whole African continent, behind Morocco (57.3%), Seychelles (57.6%), and Kenya (81.8%) (Internet World Stats, 2017). This might offer potential for introducing ICT-based monitoring of key indicators like transport, energy, and water dimensions, and hence provide real-time feedback for city controllers to readdress day-to-day strategies in an attempt to enhance the performance of the city. Such a concept forms the substance of smart cities (Helal, 2011; Hollands, 2008), but to really venture into a framework for smarting Port Louis, one needs to understand the dimension of smart cities.

Defining smart cities

The amalgam between the two words "smart" and "cities" brings forth several dimensions that encompass interconnectivity, resilience, and productivity while being conspicuous and sustainable (Riva Sanseverino, 2014). Kourtit, Nijkamp, & Arribas-Bel (2012) posited the dimension of smart people that infuse their creativity coupled with technology to enhance innovation and drive the productivity of smart cities. Townsend (2013) highlighted the concept of real-time monitoring and

feedback mechanism regulation through the use of ICT, while Batty et al. (2012 as cited in Kitchin, 2014a) added the dimension of models generation through ICT-based urban setup for simulating future scenarios. Networking among stakeholders emanates from such ICT core for real time data processing from various key indicators. Nevertheless, the economic progress must not happen to the detriment of livability and happiness of urban dwellers. The human dimension must be at the very heart of smart cities (Dominici, 2012).

Smart city in the Mauritian context is being visualized and defined as self-sustained work in a live-and-play urban context, meticulously controlled by state-of-the-art connectivity systems offering a smart transportation system (Board of Investment–Mauritius, 2016). An understanding of how the notion of smart city has been impregnated within the minds and words of urban stakeholders is crucial to the unfolding of the proposed framework.

Evolution of ideas from a classic urban setup to a smart one

Smart city aims at integrating 21st century technology towards the betterment of urban life quality. To infuse such a concept within the century old foundations of Port Louis will entail a Herculean task. To smooth such a vision and hopefully, a soon-to-be mission, let us ponder the primordial soup that engendered such a concept. Understanding the origins might provide tangible indicators of where to gear the framework formulation for Port Louis. Greenfield (2013 as cited in Kitchin, 2014a) postulated that the foundation for smart city concept came to light within mid-20th century high modernist urban planning. However, Bollier (1998) claimed that such an appellation came into existence through the Smart Growth drive during the last decade of the 20th century. Such a view has been further supported by other studies (Vanolo, 2013; Wolfram, 2012). Kitchin (2014a) postulated that the smart city concept is a technological revisit of neo-liberal urban ideologies together with the very conception originating from the advent of ICT into urbanism, and fervently warned about the hidden agenda of ICT-pro companies that advocate for better humane urbanization while their main concern is the capital derivatives of smart cities. This Author also drew a thick line under the possible technocratic control that ICT-based monitoring might offer to governmental bodies. On a rather contrasting standpoint, other studies see the potential benefits of smarting cities (Letaifa, 2015; Kourtit, Nijkamp, & Arribas-Bel, 2012; Riva Sanseverino, 2014), but we should carefully avoid any potential loopholes that the smarting up process may pose.

THEORETICAL BACKGROUND

Cognizance for smarting up cities is gaining global momentum and literature details various models used for such a goal. One model that integrates human dimension in a pronounced manner is proposed by Nam & Pardo (2011). They reviewed evolutionary dimensions of cities throughout literature and brought in the three main factors they consider fundamental for a smart city approach (Figure 2).

Technology factor

The technology factor is ubiquitous in every smart city models due to the integral ICT component that offers a transformative power within city life (Hollands, 2008). Batty (2013) hailed technology in its ability to make sense of "big data" and hence allow better urban

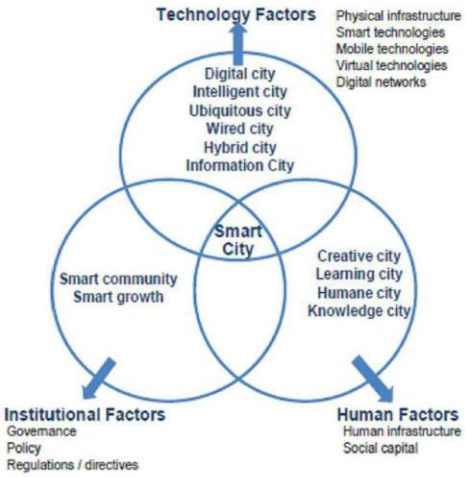

Figure 2. Smart city essential dimensions, Nam & Pardo, 2011 (Image sourced by the Author).

decision-making. The concept of big data generation within a smart city has also been praised as improving the life quality of citizens (Boulos & Al-Shorbaji, 2014). However, there are potential risks associated with the availability of data on how the city interacts that could lead to confidentiality and privacy issues (Batty, 2013; Kitchin, 2014b).

A sword of Damocles hanging on the balance is the need for a huge technical input from engineers to maintain an Information Technology (IT) infrastructure within a smart city. This could be achieved through the implementation of sensors to each energy-consuming component within the city to understand the evolution and dynamics of the energy profile of a city. Helal (2011) extrapolated on his vision of IT within smart cities by coupling the need of an IT footprint with the integration of a new generation of embedded operating system within each sensor. These new operating systems will allow the whole IT infrastructure to be interconnected in real-time similar to an ecosystem. Such smart operating systems for smart IT components will unleash the full potential of the technology component within an urban setup. Nam & Pardo (2011) recognized the positive influence that such technologies will provide to city residents. Nonetheless, ICT and the technology components may be hallmark features of smart metropolises, but without a proper institutional framework in terms of governance and regulations, the whole system may collapse (Helal, 2011).

Institutional factor

Chourabi et al. (2011) identified governance as one key dimension of smarting a city. This line of thought is shared by Paskaleva (2009) who proclaimed the central role of electronic governance (e-governance) as a driver for an emerging smart city. Nam & Pardo (2011) went further and highlighted that a smart city is not only a status, but also a continual progress originating from the very core of the city itself. These Authors stipulated that evolution in managerial strategies and policy-making is a key stage towards smarting a city.

The huge amount of big data fed into the system from the numerous sensors of the ICT infrastructure needs to be analyzed and used judiciously to meet the demands and vision of the city. This is where the institutional factor comes into play. Deakin, Lombardi, & Cooper (2011) reviewed the central role played by e-governance in light of the IntelCities Community of Practice (CoP) for electronically instilled services across European cities.

These Authors highlighted the enhanced dimensions that e-governance will provide to its citizens in terms of: i) upgraded data quality; ii) a round-the-clock supportive service to citizens and trades; iii) promotion of a state-of-the-art urban management system through a network of local authorities, regional governance, and utility providers, and iv) enhanced participative role of customers (citizens and trades) in a more inclusive decision-making process. However, there is another side of the governance coin. Data being provided from the city can be wrongly utilized by the governing bodies in various ways. Several Authors warn about how the huge flow of real-time data will make patterns predictable that may, in a worst-case scenario, give rise to a form of surveillance within a technocratic governance (Kitchin, 2014a; 2014b). Haque (2012) extrapolated on the availability of data as a means to propose an algorithm-processed governance, which might be used as a shield by governing bodies against ethical claims of dubious decisions. Kitchin (2014b) has shed a note of caution for such governance, which he described as being "narrow, reductionist and functionalist".

For instance, technocratic governance fails to consider the cultural dimensions of a city within the delicate balance of policy and politics, hence algorithmically processed governance will not be able to address the root cause of problems (Kitchin, 2014b). Vanolo (2013) put forward the "moral obligation" that needs to be displayed by citizens as being instrumental for a smart city to flourish. This lays the onus on the human factor within smart cities.

Human factor

Barrionuevo, Berrone, & Ricart (2012) recognized the essential role of the human factor in any urban progress. They stressed three crucial factors that the human dimension infuses into urban development: i) participation; ii) intelligence, and iii) proactivity. Nam & Pardo (2011) explicitly highlight the importance of human capital in smart cities because it catalyzes change through infusion of creativity and education. This view is shared by Malek (2009) who introduced the concept of "humanware" as a key indicator for development of smart cities through the "Informative Global Community". Also, Letaifa (2015) exalts the role of social capital acting as a "smart people" impetus. Smart is the diversity of ethnicity and cultural background, and the values pertaining to "tolerance, creativity and engagement". Aribilosho & Usoro (2016) related the human factor and the way it interacts in smart cities as being a "serious factor" for efficacy.

Though literature stressed the relevance of ICT-infused infrastructural components and e-governance, it should be clear that the purpose of the smart city is not to build a market by creating demands for state-of-the-art technologies. The goal is rather sustainability in the wake of such grim predictions for humankind based on climate change indicators. Thus, the human capital factor should be at the very core of any model aimed at smarting cities (Dominici, 2012).

Cohen (2012) has proposed another model, which greets the central position of people within a smart city setup (Figure 3). This model is depicted as a wheel with six spokes that highlight six dimensions of a smart city: i) smart people; ii) smart economy; iii) smart environment; iv) smart government; v) smart living, and vi) smart mobility.

Cohen's six pillars are further broken down into three indicators each (Figure 3). For instance, a smart economy revolves around innovation, entrepreneurship, productivity, and internationalization of markets, while achieving a smart environment involves adoption of green energy, buildings, and urban planning. This model caters to smart living by highlighting the need to achieve a culturally

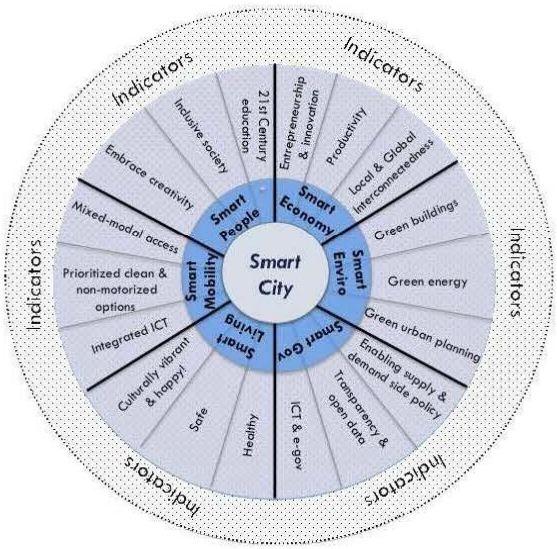

Figure 3. Cohen (2012) smart cities wheel (Image sourced by the Author).

vibrant society with a prime focus on heightened quality of life. In the same line of thought, Cohen's model calls for smart mobility and smart governance. These need the right policies and transparent data flow within an ICT infused e-government environment. Cohen also calls on smart people to focus on creativity within an inclusive society and the right educational setup. Lekamge & Marasinghe (2013) reviewed Cohen's model in light of its implementation as proposed by the Author himself. The first step involves setting up a vision, which takes into consideration the current state of the city and where it wants to position itself. Furthermore, baseline data needs to be collected and analyzed with an appropriate target and set course of action. The latter can be achieved through the adoption of best practices of existing cities, but Cohen warns to consider the uniqueness of each city in terms of population density, topography, and existing infrastructure. Moreover, Cohen (2012) stresses clearly the need to set achievable targets while proposing a long-term course of action.

Literature points out to some key providers such as IBM, which focuses on a tripod model. This includes: i) the people; ii) the infrastructure, and iii) planning and management (Figure 4). IBM (n.d.) explains planning and management as "long-term insights based on comprehensive data analysis, followed up through efficient daily management, [that] help a city stay vital and safe for its citizens and businesses". The five key indicators for such a pillar in IBM's model include: i) public safety (emergency management); ii) public safety (law enforcement); iii) smarter buildings; iv) city planning and operations, and v) government and agency administration. The infrastructure dimension of IBM's model consists of three main themes acting as key indicators: i) water; ii) transport, and iii) energy. In all previous models discussed above, people form a major pillar with key indicators revolving around: i) social programs; ii) healthcare, and iii) education.

On the same course of action, Hitachi uses a human-centered approach to smarting up cities aimed at: i) improving quality of life through better public safety within an economically viable and sustainably vibrant community; ii) increasing resiliency that promotes quick adaptability to immediate changes while being proactive on long-term issues, and iii) operating efficiently through

Figure 4. IBM (n.d.) smart city model (Image sourced by the Author).

smart use of technology, while cutting down on energy consumption and optimizing transportation times (Hitachi, 2016).

Based on the above literature, it is apparent that smarting up cities can happen through various models, but all have an ICT core aimed primarily at enhancing livability. To be able to choose one that will be most adapted for the capital city of Mauritius, we need first to understand the uniqueness of Port Louis.

FRAMEWORK FOR PORT LOUIS

In a bid to integrate Port Louis people within the smarting up process, and ensuring achievable goals through a "go lean" approach as preconized by Cohen (2012) I have considered to focus on the IBM model.

Key is the human capital of the city. The mission is to promote the capital of Mauritius as a vanguard smart city with smart people in a smart setup geared towards state-of-the-art living standards. It goes without saying that this vision needs to be scrutinized by scholars within various fields, but also by the residents and workers of Port Louis. Such an aim extends beyond the scope of this paper to open avenues for future venture. Once the vision is set, the dimensions of the smart city within the selected model need to be clearly stipulated.

The People

For this dimension, key indicators identified are i) social programs; ii) smarter care, and iii) education. Besides offering a melting post of cultures, Port Louis is punctuated with several historical landmarks including the UNESCO world heritage site and the Aapravasi Ghat. Moreover, the human dimension of Port Louis includes commuters from several other districts together with the local population (Table 1). Human infrastructure concerns social learning and education (Nam & Pardo, 2011). Social learning is based on a theory proposed by Bandura (1971) that principally

argued that the learning process can occur by observation within a social setup. The social setup is the cultural identity of the capital city with its historical sites.

The cultural glue of such process is sustainability. It needs to be conspicuous enough to reach the population. This is where Maslow's hierarchy of needs is useful. Maslow's hierarchy of needs (Lekamge & Marasinghe, 2013) is a series of dimensions that drives someone towards a certain behavior. The most fundamental dimension is physiological need, whereas the most essential is self-actualization.

This is in line with the proposal of Lekamge & Marasinghe (2013) who stipulated that no progress can be achieved if the needs and wants of citizens are not met. In order to move in such a direction, a well-established theoretical framework must act as anchorage, and so Maslow's hierarchy of needs has been proposed.

For Port Louis, the education within a social setup is more informal and attitude-based. Since the focus is on smart setup, there should be reinforcement of such an approach by designing tailor-made campaigns to inculcate the values pertaining to an ICT-infused culture within a smart setup. For instance, Krätzig & Warren-Kretzschmar (2014) lauds the opportunities that social media, like Twitter, can have in participatory planning and communication.

Unlike megalopolises where most of the inhabitants stay within the same city they work, Port Louis experiences a huge number of commuters coming from other regions everyday (Table 1). The focus on sustainable education within a smart setup should therefore be a national drive. In promoting an education for inculcating sustainable culture, several factors should be considered. In the wake of the 21st century, with the huge opportunities that ICT provides and with the Z generation of students, the whole teaching and learning process should be readdressed. Beetham & Sharpe (2013, p. 6) recognized such a need and argued that two dimensions of education should be pondered, i.e. pedagogy and design. These two dimensions will promote a contextualized 21st century educational system to introduce the values of sustainability within a smart setup. So do Nam & Pardo (2011) when urging to promote ICT within the core of educational curriculum.

The human factor within a smart city also includes creativity and a social capital dimension. Simpson (2005) postulated social capital as positive outcomes resulting from core community-based values backed by strong social networks, sense of belonging, and committed leadership. The Author further explained that robust social capital is achieved by the recognition of diversity and through adoption of a socially inclusive community. Effective ICT skills are essential to promote the concept of social capital (Simpson, 2005). To achieve such a crucial step for Port Louis, citizens and people coming to work need to feel this sense of belonging. Port Louis should be appealing, safe, and conspicuous. The heavy, noisy traffic and the lack of pedestrian friendly zones, green spaces, and upgraded living environments make the capital city very far from conspicuous (Guttee, 2015). As such, a SWOT analysis has been carried out to highlight the key strengths, weaknesses, opportunities, and threats that the people in the chosen model may offer (Figure 5).

The SWOT analysis for the people dimension highlights that core strength and opportunities reside on the cultural diversity of Port Louis and the possibility to introduce educational reforms. However, cultural diversity may also be a threat owing to the inherent difficulty of satisfying the needs for each socio-cultural group in the capital city. Moreover, education policy cannot be applied to one city only but should be a national drive. Despite stakeholders strongly want to move ahead

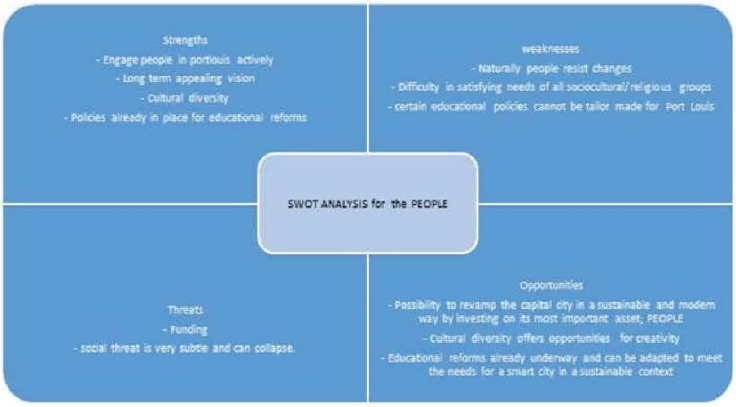

Figure 5. SWOT analysis for the human dimension (Image sourced by the Author).

and smart up Port Louis, issues of funding is a hindrance. There needs to be public-private partnership to provide the means to investing in human capital as proposed by Vanolo (2013). Although the human dimension holds a key place in the proposed model for Port Louis, nothing can really be achieved if there is not thorough planning and management to gear the city towards its smart vision.

Planning and Management

Smarting up the city will entail data. The huge flow of data that is generated in a smart city needs proper policies and governance to be meaningfully utilized. This dimension of the proposed model for Port Louis has four key indicators in the form of: i) public safety, ii) government and agency administration, iii) city planning and operations, and iv) buildings. Governance for a smart city needs to serve the demands of the community, but this should occur within a proper policy framework. Allwinkle & Cruickshank (2011) highlighted the central role of government in the Amsterdam city project aimed at saving energy and studied e-government in Edinburgh. They showed that governance is mainly linked with the vision. Singapore's model could be helpful in this respect. The main asset of Singapore has been its people, and how the government has focused on developing policies for promoting human and social capital with key guidelines for a sustainable culture. These sustainable programs aimed principally at reducing greenhouse gas emissions and traffic in a bid to enhance livability (Kogan & Lee, 2014), a goal that Port Louis must also share.

Another major dimension of governance is transparency and open data. Nam & Pardo (2011) strongly highlighted the need for the government to share a vision and even a strategic plan with all the stakeholders. Moreover, these Authors show the need for strong leadership at the helm to guide any city through the smarting up process. Strong leadership will promote interrelatedness among all the stakeholders, while keeping the way data and policies are being processed in full transparency. A SWOT analysis has been performed for this dimension to shed some light on potential loopholes and avenues for advancement.

Based on the SWOT analysis (Figure 6), it is quite apparent that there are serious strengths and opportunities to drive the planning and management process ahead through active public-partnership as said by Nam & Pardo (2011) and Vanolo (2013). However, not all policies may be

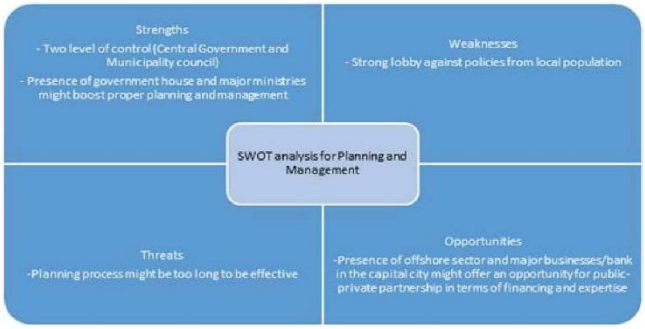

Figure 6. SWOT analysis for Planning and Management (Image sourced by the Author).

fully accepted by the local population and this could lead to some strong resistance. Such resistance might eventually hinder the planning process and if this extends over five years and a new administration comes into power, then the planning process may even turn out to take more time. Although human factors and institutional dimensions have major parts to play in turning the capital city of Mauritius into a smart one, there needs to be a state of the art ICT core within the very foundations of any framework for such an endeavor.

Infrastructure

Infrastructure remains a central issue. Connectivity through Web 2.0 technologies propose infrastructural challenge for smarting up the capital city of Mauritius. Such an aspect needs to be cared for in order to integrate systems that will lead to smart management of water, energy, and transportation indicators falling under such a dimension of the proposed model. Lövehagen & Bondesson (2013) offered specific guidelines for impact assessments of ICT key indicators. They suggested that key indicators be manageable with data sets from which baselines could be defined within a transparent setup. Moreover, these Authors insisted on the need for clear data of life cycle dimension for ICT solutions together with realistic aftermath consideration for implementation of any urban ICT component. Once the sustainability component has been resolved, one can consider the transformation that ICT will provide for Port Louis.

Mauritius boasts high-speed internet connectivity, and this trend has kept increasing for the past decade. Enhanced connectivity is crucial for a smart city. However, there are other key indicators to consider. In that sense, Schaffers et al. (2011) proposed the concepts of smart transport, smart grid and environmental monitoring.

Port Louis is congested and has few parking spaces available during the daytime. This creates a noisy environment coupled with enhanced greenhouse gas emissions. The dense urban setup delimits wind flow resulting in an over-dependence on air conditioning for both residential and business buildings. Solutions exist and some are already being substantiated, like the introduction of a metro system to alleviate the transport situation and the introduction of the Sea Water Air Conditioning System (SWAC), which uses cold water from the ocean for air-conditioning (OTEC Foundation, 2014).

Smarting up Port Louis will entail the introduction of monitoring systems with a smart management system to promote enhanced productivity and performance within an upgraded livability core. To

meet such an end, Gubbi, Buyya, Marusic, & Palaniswami (2013) proposed the use of a Wireless Sensor Network (WSN) that offers real time data capture. These data could subsequently be analyzed to promote a Common Operating Picture (COP). Such an integrated system is what the Authors referred to as the Internet of Things (IoT) and they lauded its potential application in a smart environment context for the welfare of citizens in the City of Melbourne (Table 2). Implementation of such an integrated system for Port Louis needs to be considered within the right institutional (governance and policy) setup embedded within the ties of transparency and accountability to make the capital city of the island smart.

Citizens	
Healthcare	triage, patient monitoring, personnel monitoring, disease spread modelling and containment - real-time health status and predictive information to assist practitioners in the field, or policy decisions in pandemic scenarios
Emergency services, defence	remote personnel monitoring (health, location); resource management and distribution, response planning; sensors built into building infrastructure to guide first responders in emergencies or disaster scenarios
Crowd monitoring	crowd flow monitoring for emergency management; efficient use of public and retail spaces; workflow in commercial environments
Transport	
Traffic management	Intelligent transportation through real-time traffic information and path optimisation
Infrastructure monitoring	sensors built into infrastructure to monitor structural fatigue and other maintenance; accident monitoring for incident management and emergency response coordination
Services	
Water	water quality, leakage, usage, distribution, waste management
Building management	temperature, humidity control, activity monitoring for energy usage management Ð Heating, Ventilation and Air Conditioning (HVAC)
Environment	Air pollution, noise monitoring, waterways, industry monitoring

Table 2. Potential IoT applications for the City of Melbourne
(Gubbi, Buyya, Marusic, & Palaniswami, 2013) (Table sourced by the Author).

A SWOT analysis for the infrastructure dimension offers further insight into the third pillar of the proposed model for smarting up Port Louis (Figure 7).

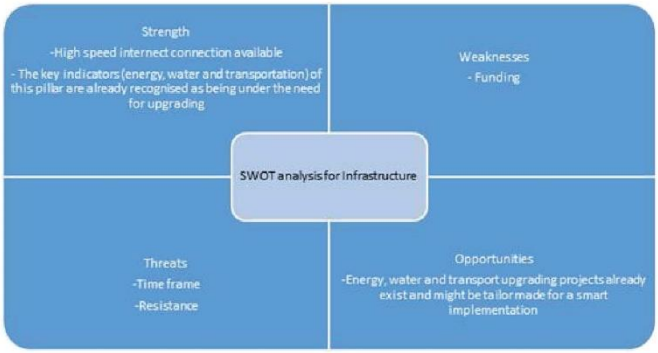

Figure 7. SWOT analysis for infrastructure domain (Image sourced by the Author).

The major strengths and opportunities for the infrastructure pillar of the IBM model revolves on the fact that studies have already been conducted on all three key indicators of such a dimension

(Welsch et al., 2014) and simply need to be tailor-made. For instance, Mauritius has tremendous potential in developing renewable power sources such as wave power, ocean thermal energy conversion (OTEC, 2014), solar photovoltaic, and wind power (Hammar, Ehnberg, Mavume, Cuamba, & Molander, 2012). Further, Khoodaruth, Oree, Elahee, & Clark (2017) point to the possibility of enhancing the self-sustainability of Mauritius for energy. As said before, however, a major hurdle remains the cost, the resistance from local population, and the time schedule of projects for efficient implementation. One possibility to circumvent the funding issue, besides looking for public-private partnership, is to pay for the service rather than pay for the whole setup. Such a solution exists, e.g. Hitachi offers smart transport solutions as a service (Hitachi, 2016). Resistance from local population and timeframe issues can be alleviated through proper planning and management of the system.

The next step in the smarting up process needs a proper model for efficient implementation. To this end, the SMART model (Figure 8) proposed by Letaifa (2015) has been noted. It works at micro, meso, and macro levels and encompasses all three dimensions of the IBM proposal while placing citizens at the very core of the smarting up process. On the macro level, the focus is on scope and mindset upgrading by developing a proper strategy within a multi-disciplinary team backed by strong political sponsorship under expert leadership. Meso level will involve appropriation of the project by key actors and generation of roadmaps to meet the end of the smarting up endeavor. Eventually, on the micro level, the right technology will be identified and projects launched for their smooth integration. At all levels, the focus must be on transparency, accountability, and performance.

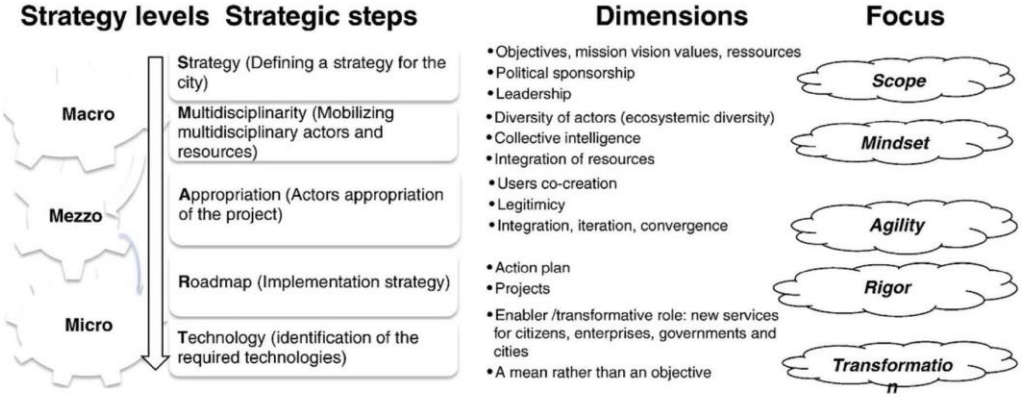

Figure 8. The SMART Model (Letaifa, 2015) (Image sourced by the Author).

CONCLUSION

The aim of this study is to propose a conceptual framework for smarting up the capital city of Mauritius based on the IBM model. Such a model consists of three major dimensions: i) people; ii) planning and management, and iii) infrastructure. Each dimension comes with specific indicators. For instance, the people dimension lays emphasis on social programs, education, and smarter care, while energy, water, and transportation issues are showcased under the infrastructure banner. The planning and management pillar revolves around indicators linked to public safety, government and agency administration, and city planning and operations together with buildings within the city. For

a smooth implementation, the SMART model has been proposed, which caters to macro, meso, and micro levels of the smarting up process. One needs to consider all the strata of policy and planning within Port Louis while respecting the chain of command through efficient leadership and regulation at every stage of the smarting up process.

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Economically Incentivising Smart Urban Regeneration. Case Study of Port Louis, Mauritius

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Abstract: Port Louis, the capital city of Mauritius, has been the preferred city for hosting the judicial, political and business activities of the country for the past two centuries. However, new policies have created nine new smart cities in greenfield locations within 10 km from Port Louis, so the capital city is facing economic decline as it is losing businesses, as well as administrative functions. This loss equates to an erosion in municipal revenue along with a reduced interest in contributing to the development of the city; all of which takes a toll on its urban economic landscape, as well as on the broader Mauritian economy. This paper builds from the findings of a focus group study to propose a smart urban regeneration model for the City of Port Louis, which could enable the old city to be restored and regenerated rather than redeveloped in modernist architecture, as has happened in the new smart cities model. A smart urban regeneration model is proposed backed by the pillars of smart infrastructure, culture, metabolism and governance. The proposed model is applied to the context of Port Louis to generate an urban regeneration scheme. The potential benefits in terms of financial outcomes, investment attraction and job creation are explored through a combined application of econometric forecasting models. The results support positive figures of both investment and job creation, and the findings of this study aim at informing and providing the governing bodies of Port Louis with a tangible solution for revamping the centuries-old capital city, as well as demonstrating to the world that smart cities can mean sensitive urban regeneration.

Keywords: urban regeneration; economics; culture; port louis; smart cities; fiscal measures

1. Introduction

Nested in the North-West littoral side of the Island of Mauritius and bounded inland by a mountain range, Port Louis extends over an area of 46.7 km^2. With a total population of 119,333 inhabitants as at December 2016, the capital city of Mauritius is the most densely populated geographical district of the island with 2954 P/km^2 [1]. Port Louis hosts the only trade port of the island and has been the main administrative centre from a judicial, political and business perspective for more than two centuries. However, within the last decade, there has been an emergence of Techno-parks and privately-owned smart cities across the island which opened a new competitive landscape for businesses and administrative functions [2]. There have been notable highlighted risks that the loss in business and administrative functions from both the state and privately-owned organisations will eventually lead to an erosion in municipal revenue [3]. Lesser financial input will trickle down to lesser budget availability not only for city development but also for its maintenance. This might lead to an increase in urban decay, as has been the case with Detroit in USA [4]. In fact, at the moment more than 95% of municipal revenue is used for administrative ends such as salaries for the employees and the government lacks funds to be injected in existing cities [5].

The potential of the city has been hailed by many [3,5,6]. In fact, Port Louis has long been a vibrant city with rich historical, cultural and multi-ethnic dimensions which cannot be matched elsewhere in the island [7]. However, the cultural dimensions have greatly suffered from the lack of public funds and numerous heritage buildings are at risk [8]. With both the public and private sector losing interest to invest in the capital city, there is a notable trend of urban decline.

To catalyse urban regeneration through private investment in the public domain, an Urban Regeneration Scheme (URS) was proposed to the Government of Mauritius by Gaetan Siew, from the Port Louis Development Initiative (PLDI), in partnership with the first author. The URS was developed built from findings from a focus group including key stakeholders who were asked how smart city technologies could be used to help regenerate an old city like Port Louis rather than build a modernist new town in greenfields as has happened with new smart cities in Mauritius. An URS was devised for the city of Port Louis with the aim to catalyse investment and job creation, and the potential application was calibrated in accordance with local regulations.

2. Methodology

This paper builds on the findings of a focus group study conducted by Allam [9] aimed at regenerating the urban fabric of Port Louis using smart city technologies and approaches. An extensive literature survey was undertaken in a previous publication [10] where a smart cities framework was proposed. The smart cities framework as outlined by Allam and Newman [10] is coupled with the interpretation of findings from the focus group by Allam [9], leading to a more inclusive model: the smart urban regeneration framework. Based on this new model, a URS aimed at regenerating the urban fabric of Port Louis is proposed using smart city concepts. The URS consists of a fiscal package of incentives applicable to a designated Action Plan Zone (APZ). An economic quantification is followed to measure the impacts of the URS on the urban economy of Port Louis through investment, municipal revenue, business and jobs' creation. Figure 1 summarises the methodological approach for this study.

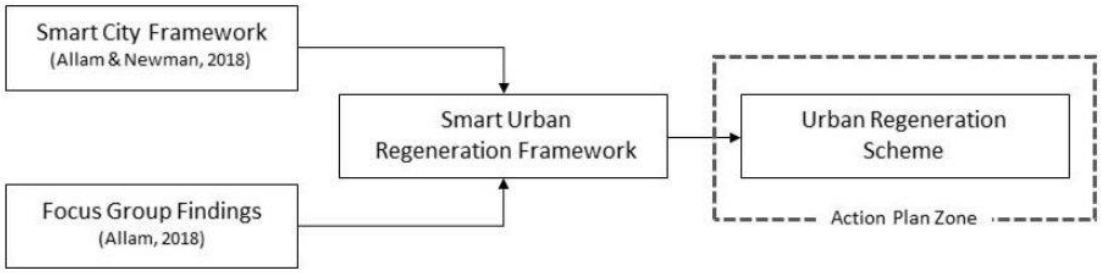

Figure 1. Methodological approach for creating a smart urban regeneration model.

3. Focus Group Findings

3.1. Six Dimensions for Smart Urban Regeneration

The focus group consisted of 31 participants from both the public and private sector employing approximately 24,388 people, where 52% work in the city and 73% transit through the city of Port Louis at least once per day. The group provided six dimensions for how smart city technologies and approaches could be directed towards new outcomes that could assist urban regeneration; the results were detailed in Allam [9]. The six dimensions are: (1) business support; (2) smart infrastructure; (3) governance; (4) metabolism; (5) collaboration; and culture. Figure 2 illustrates the six dimensions in their order of prevalence from the focus group discussion.

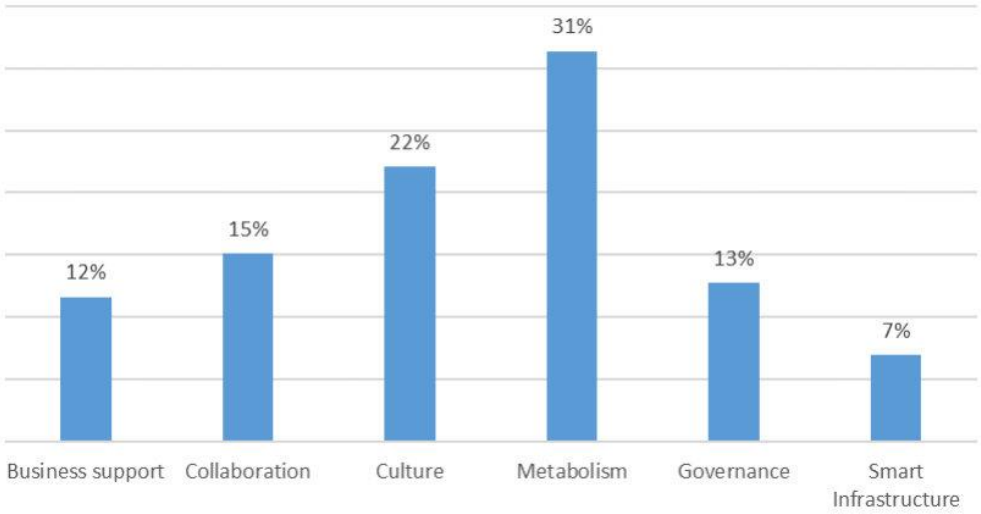

Figure 2. The Six identified dimensions for smart urban regeneration, featured in popularity [9].

3.2. Incentives

The focus group highlighted the importance of fiscal incentives as a policy tool for economic regeneration and a business catalyst. Tax incentives are well documented through Special Economic Zones (SEZs) in various parts of the world and have been proven to attract investment and create jobs [11–13]. Moreover, the rapid regenerative growth can be an attractor for global entrepreneurs who are looking to take advantage of the fiscal incentives offered by government, as this adds a component of trust [14]. Global entrepreneurs have been taking advantage of the liberal tax incentives offered by the government to set up world-class units in these special zones to service the international markets [11]. In Mauritius, fiscal incentives are applicable for smart cities and the freeport, but not for urban regeneration projects, or development in existing cities like Port Louis.

3.2.1. Smart Cities

Through the National Budget of 2014, the Government of Mauritius announced the creation of a series of smart cities. Those were set with a potential to catalyse over USD 3.5 billions in investment during the following years [15]. The strategy was aimed at boosting socio-economic development of the island [16]. Such a project had typical objectives of upgrading the quality of life through innovative practices and implementation of new technologies, but it was directed at greenfields sites. Allam and Newman [10] highlighted nine smart cities on the edges of Port Louis following a modernist New Town tradition. A series of fiscal incentives, showcased in Table 1, were applicable to encourage the investment in smart city projects.

3.2.2. Freeport

Within the last two decades, several major projects, under the aegis of the Mauritius Ports Authority [17], came to light including the creation of over 100 hectares of land through reclamation works and the creation of the Mauritius Freeport Sector [17]. This promoted Mauritius (and Port Louis) as a hub for international trade, where several fiscal incentives are proposed for companies seeking state of the art facilities for storage, assembly and redistribution [18]. Table 2 highlights the various incentives as applicable to port activities.

Table 1. Smart city incentives by the Government of Mauritius [15].

1	A smart city company (holder of Smart City Scheme Certificate) is exempted from the payment of: (i) income tax for a period of 8 years from the issue of the SCS Certificate provided that the income is derived from an activity pertaining to the development and sale, rental or management of immovable property other than an activity with respect to the supply of goods and services (ii) land transfer tax and registration duty on transfer of land into the smart city company for the development of the smart city project, provided that the transferor holds shares, in the smart city company, equivalent to the value of the land transferred (iii) land transfer tax and registration duty on the transfer of land from a smart city company to a Special Purpose Vehicle (SPV) set up to develop a component of the smart city project, provided that the smart city company holds shares in the SPV, equivalent to at least the value of land transferred (iv) land conversion tax with respect to the land earmarked for the development of non-residential components (office and business parks, Information Communication Technology (ICT) and innovation clusters, tourist, leisure and entertainment facilities including hotels and golf courses, renewable energy and green initiatives) (iv) land conversion tax with respect to the land earmarked for the development of non-residential components (office and business parks, ICT and innovation clusters, tourist, leisure and entertainment facilities including hotels and golf courses, renewable energy and green initiatives) (v) valued added tax with respect to buildings and capital goods (vi) customs duty on the import or purchase of any dutiable goods, other than furniture, to be used in the infrastructure works and construction of buildings under the smart city scheme (vii) morcellement tax for the subdivision of land
2	A smart city company issued with a SCS Certificate is granted accelerated annual allowance at a rate of 50% of the costs with respect to capital expenditure incurred on: (i) renewable energy (ii) energy-efficient equipment or noise control device (iii) water-efficient plant and machinery and rainwater-harvesting equipment and system (iv) pollution control equipment or device, including wastewater recycling equipment (v) an effective chemical hazard control device (vi) a desalination plant (vii) composting equipment (viii) equipment for shredding, sorting and compacting plastic and paper for recycling
3	The smart city company may sell serviced land to another company to develop a component of the smart city project
4	Application for the permits and licenses submitted by the smart city company will be facilitated through the Board of Investment One Stop-Shop and fast tracked through the Investment Projects Fast-Track Committee
5	Sale of immovable property can be made by way of 'Vente en Etat Futur d'Achevement' (VEFA) or 'Vente a Terme'
6	Land transfer tax for immovable property sold on VEFA is payable in four 6-monthly instalments

Table 2. Freeport incentives by the Government of Mauritius [18].

1	A zero-rate tax on corporate profits
2	Exemption from customs duties and value-added tax on all goods and equipment imported into the freeport zones
3	Reduced port handling charges for all goods destined for re-export
4	Free repatriation of profits
5	100% foreign ownership allowed
6	Possibility of selling a quota, 50% of the total value for customs purposes of the goods re-exported or exported in any period of 12 months, on the local market (Section 7 (5) of the Freeport Act 2004). However, profits generated from these transactions will be taxable at the normal corporate tax

Such incentives are backed by six main regional and international trade agreements such as: (i) the Common Market of Eastern and Southern Africa (COMESA); (ii) the Southern African Development Community (SADC); (iii) African Caribbean and Pacific (ACP)-Cotonou agreement; (iv) African Growth and Opportunity Act (AGOA); (v) Indian Ocean Commission (IOC); and (vi) Indian Ocean Rim Association for Regional Cooperation (IOR-ARC). These agreements consolidate commercial power of

the Mauritian port and promote the concept of a worldwide free trade zone where trade occurs between economic blocks instead of individual countries [18]. Within such clearly-defined and well-oiled trade boundaries, the port area of Port Louis celebrates a highly efficient and business-friendly zone. This efficiency is also defined in terms of year-round 24-h logistics, emergency and security services, including value-added amenities for cargo handling [18]. However, it did not extend into the main urban area of Port Louis where urban regeneration is needed.

The bunkering sector, as part of the port, is being hailed as a potential candidate for an extra economic pillar for Mauritius [19]. This aligns with the government's Vision 2030, which aims at promoting the island as a petroleum and bunkering hub. A new framework offers several incentives to this end: (i) facilities for private entities to import their own products; (ii) exemption of excise duty, value-added tax and specific levy for bunker fuels; and (iii) discounts on port and ancillary fees together with facilities to carry out secondary activities such as crew changing [19]. These incentives have resulted in a 60% growth in importation of bunker fuels from 2014–2017 [19]. This is also not helping the old urban areas of Port Louis.

3.3. Opportunities for Urban Regeneration

Urban regeneration is the opposite of what has happened in smart cities in Mauritius. It is based on steel and glass high rise towers that sit in a landscape that is totally car dependent and not very walkable across the precinct. Such development is not appropriate for the old city of Port Louis, which has many historic buildings and precincts [20,21]. This paper is trying to determine how smart city technologies and approaches could be used to fit into the old urban fabric and enable it to be restored and regenerated rather than being redeveloped in modernist architecture.

Allam [9] underlines two major policies that are sought to negate modernist urban re-development in the old part of Port Louis, but which could become the basis for smart city regeneration: the buffer zone of the Aapravasi Ghat [22], and the Landlord and Tenant Act [23].

3.3.1. Aapravasi Ghat Buffer Zone

Located on the harbour front, the Aapravasi Ghat Immigration Depot (Figure 3) marks the site of arrival of over 500,000 indentured labourers, after the abolition of slavery, between 1834 and 1920. The mass migration was part of the British 'Great Experiment' and was later replicated in other British colonies around the world [24]. The site was inscribed as part of UNESCO World Heritage in 2006 and only measures 1640 m^2, while its buffer zone amounts to 289,000 m^2. The buffer zone of the Aapravasi Ghat, commonly known as Buffer Zone 2 [22], is illustrated in Figure 12.

Figure 3. Photo of Aapravasi Ghat [25].

The buffer zone area is part of a very old historic district including World Heritage sites where little development has been attracted to help restore some of the highest value heritage buildings in the world as showcased in Section 3.3.2. The area is a major urban regeneration opportunity. However, the area is not attracting investment as business is scared off by powerful heritage-based regulations.

Development in the Aapravasi Ghat buffer zones is bound by strict regulations underlined in the Planning Policy Guidelines 6 [22], which was set to preserve the unique architectural language and the rich cultural and historic nature of the place. However, there have been numerous complaints by landowners that the imposed regulations are not conducive to profitable business models due to strict height restrictions [22,24], mainly limited to two-storey building fronts [22]. While, traditionally, real estate by the waterfront had substantial value [26], property falling in the Aapravasi Ghat zone is deemed undesirable for development [27] due to regulations that negate development [28].

With this backdrop, buildings on the waterfront face decay as owners face restrictions of a two-storey building height; thus, owners lose interest in renovating their assets as return on investment is deemed lengthy without an optimal site usage.

The purpose of this paper is to show that a new approach can be taken that brings heritage regeneration into a smart city framework and enables areas where development is restricted, like UNESCO World Heritage Sites, to be restored, thus saving the buildings, as well as enabling significant new investment in new buildings that are complementary to the heritage qualities of the old urban fabric.

3.3.2. Landlord and Tenant Act

The Landlord and Tenant Act was enforced after the devastating Carol Cyclone of 1960, which with wind gusts of 280 km/h, destroyed over 70,000 homes and rendered a death toll of 42 [29]. Figure 4 illustrates the impacts of Carol Cyclone. The act was enforced to ensure that landowners do not take advantage of the devastating situation in the form of a drastic rise in price rentals. It thus ensures a steady rental rise, under current market rates [23].

Figure 4. Impacts of Carol Cyclone in 1960 [30].

Driven by the tenant lobby, a moratorium was enacted on the Landlord and Tenant Act to prevent rental price rise. The moratorium expiration was set to expire in 2005, but with a strong tenant lobby, the Government extended the moratorium in 2017 for another three years, till 2020 [31].

The rental price of property has thus been frozen since 1962 [32] in Mauritius, where tenants enjoy a price equivalent to USD 3–15 in the city centre [33], protected from eviction, as outlined in

the Act. This policy thus impacts negatively on landowners and on the property market in Mauritius. There have been reports that highlight how Mauritian policies favour tenants over land owners [34].

This renders an environment where building owners cannot afford to renovate their building and prefer to leave it in a state of decay until tenants are forced to leave [28]. Following this, there have been numerous cases where landowners have waited for their building to crumble to demolish the site in favour of paid open-air parking, which is more profitable than a building [5]. Planning professionals believe that the Landlord and Tenant Act has been negatively impacting Port Louis over the last 50 years [3].

However, the lack of development, encouraged by both the Landlord and Tenant Act and the restrictions tied to Buffer Zone 2, is celebrated by some as the area retained its identity [5]. This has contributed to a rise in cultural and tourism attractivity due to historic buildings in the old fabric such as the Central Market (Figure 5), Port Louis Theatre (Figure 6), the Granary (Figure 7) and the Old Military Hospital (Figure 8), amongst others.

Figure 5. The Central Market, Port Louis, Mauritius [35].

Figure 6. The Port Louis Theatre, Mauritius [36].

Figure 7. The Granary, Port Louis, Mauritius [36].

Figure 8. The Old Military Hospital, Port Louis, Mauritius [37].

While some sites received government funding for restoration, Allam [38] suggests that renovation alone is not sufficient as buildings remain closed and access to city users voided. They are not going to be saved in the long run unless a significant economic activity is found to provide on-going maintenance. On the other hand, there have been a number of commendable project proposals by the private sector at those public sites aimed at protecting the cultural attributes while celebrating a financially-profitable diversity of use [3,5]. However, none came to fruition due to the lack of adequate frameworks providing attractive return to developers. Perhaps a new attempt using new technology and approaches from the smart city collection can enable such important sites to be regenerated.

It should be possible to construct a framework for urban regeneration that enables both heritage protection and urban regeneration to make the most of this area; thus, the next section suggests a possible framework.

4. The Smart Urban Regeneration Framework

Building from prior research by Allam and Newman [10] and Allam [39], the smart city framework is used in this study to show how it can be applied to urban regeneration of an old city. Allam and Newman [10] underlined the three key dimensions when applying smart cities ideas to an existing city: culture, metabolism and governance. Figure 9 showcases the smart city framework. However, the focus

group extended this in two other desired dimensions to promote an inclusive urban regenerative process (Figure 10), which provided incentives for the potential change in urban development priorities. The context of Mauritius is one where business has a history of supporting fiscal incentives as a catalyst tool for development [15,16,18]. A smart urban regeneration framework (Figure 10) is proposed where incentives are calibrated to regroup both the dimensions of business support and collaboration and further implemented to target the dimensions of governance, culture, metabolism and smart infrastructure to provide a smart city not simply with ICT alone in a kind of trickle down system of urban development. It is proposed that the two dimensions of business support and collaboration are coded as part of a proposed package of incentives and then applied to specific areas of the four dimensions of culture, smart infrastructure, governance and metabolism.

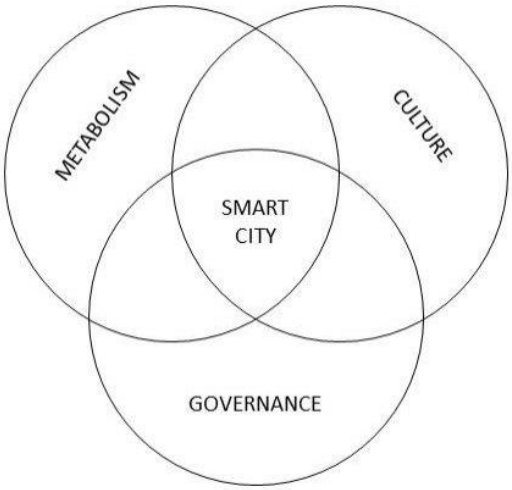

Figure 9. The Smart City Framework for Port Louis by Allam and Newman [10].

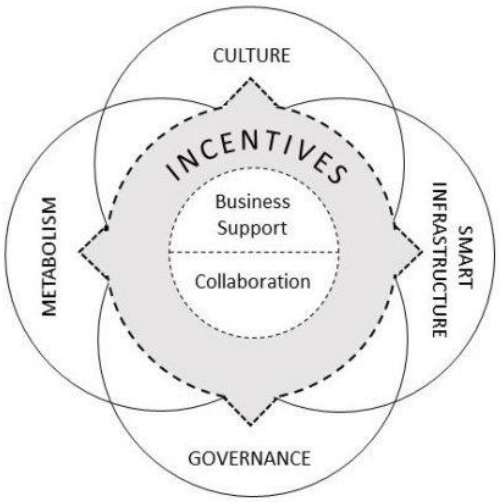

Figure 10. The smart urban regeneration framework.

5. The Urban Regeneration Scheme

A URS proposed for Port Louis is designed to follow and deliver the smart urban regeneration framework based on key areas identified by the focus group and summarised in Allam [9]. Figure 11 illustrates the URS and its linkages to the six dimensions of the extended smart framework.

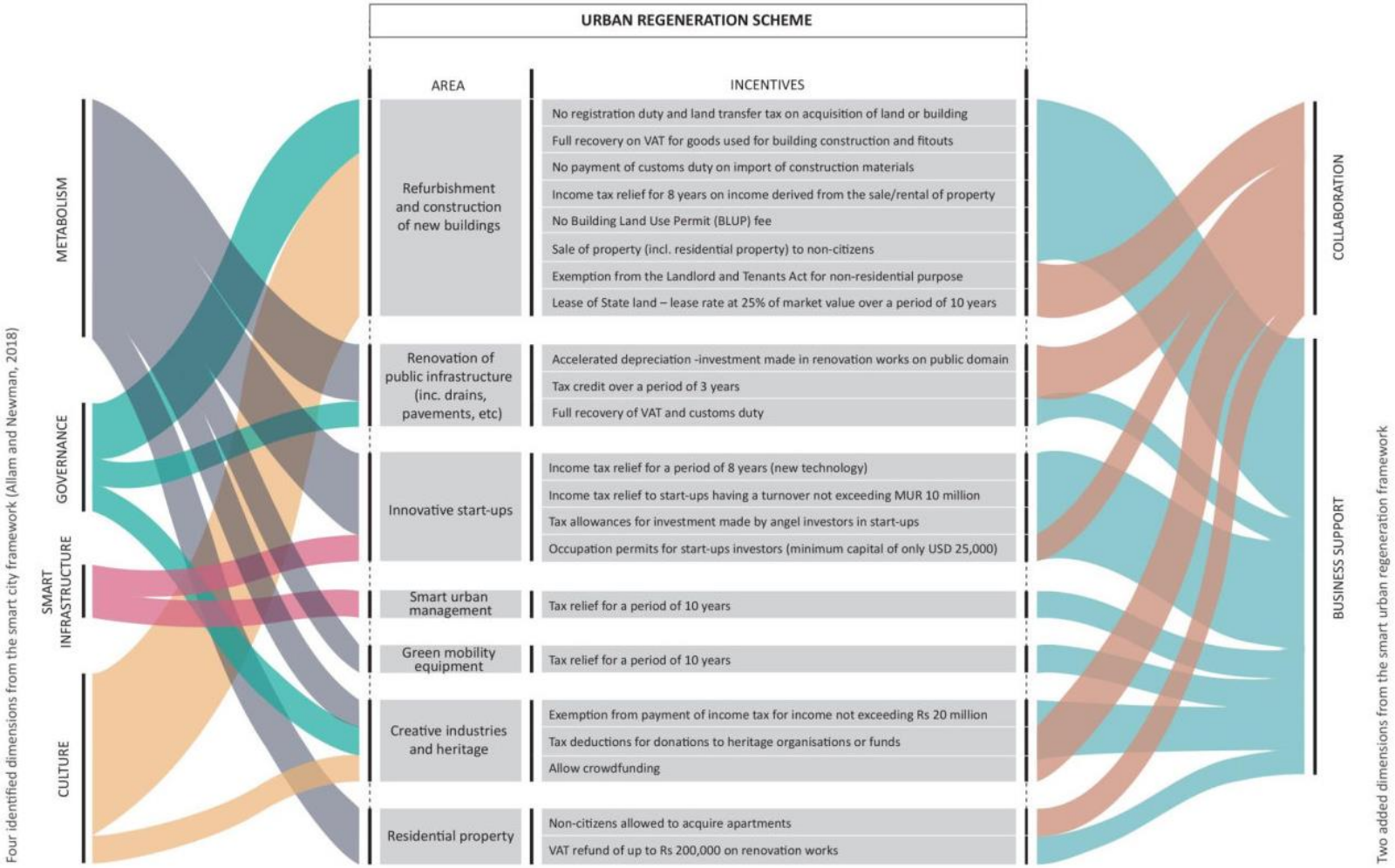

Figure 11. Proposed incentives as part of the urban regeneration scheme.

Action Plan Zone

To ensure the densification and urban regeneration of the urban fabric to create a healthier economy in the old quarter, an APZ is proposed where fiscal incentives shall be applicable. Findings from the focus group, as outlined by Allam [9], supported that the APZ should be limited to the Central Business District (CBD) of Port Louis. While there is no official designated boundary for the CBD, the Port Louis Outline Scheme [40] defines a 'Core Zone' as showcased in Figure 12 below. However, the Core Zone does not include part of the waterfront and the heritage district, which falls under the Planning Policy Guidelines 6 [22], as part of Buffer Zone 2 of the Aapravasi Ghat, as outlined above. For ease of interpretation, adoption and future possible integration in Mauritian legislations, the APZ is defined by the boundaries of the Core Zone coupled with that of Buffer Zone 2.

Thus, the smart urban regeneration model is delivered by an urban regeneration scheme (using planning and economic tools) and is applied to the APZ. The next sections set out how they use smart city technologies and processes.

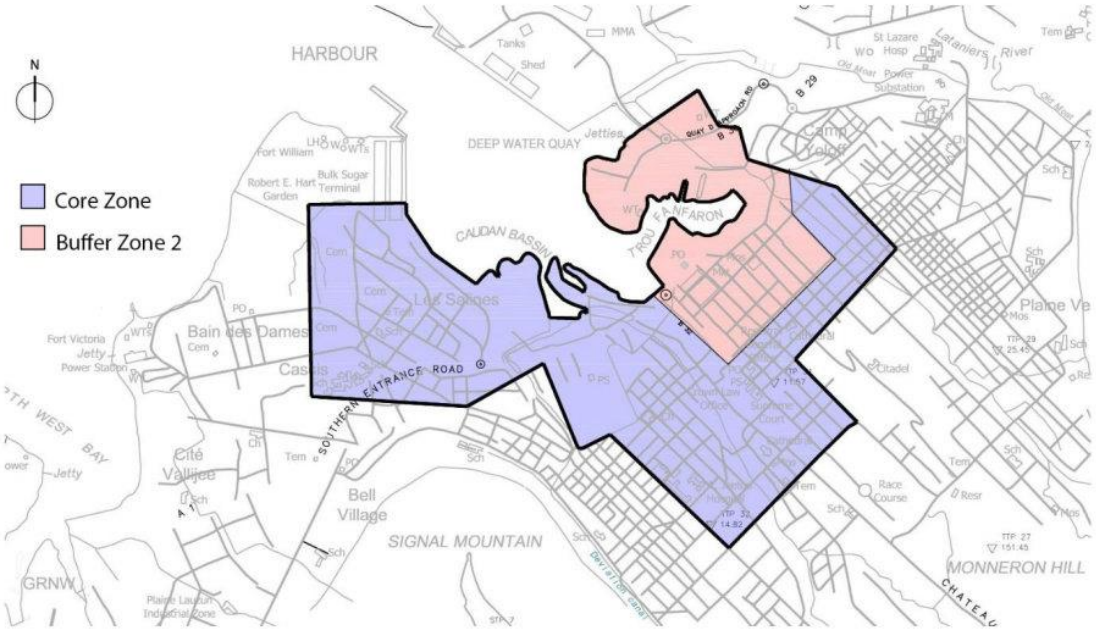

Figure 12. Action Plan Zone (APZ) as a combination of both the Core Zone [40] and Buffer Zone 2 [22]. Illustration by the authors.

6. Application of the Smart Urban Regeneration Model to the Action Plan Zone

The smart urban regeneration model aims to help bring life back to the area in Figure 12. It hopes to improve culture, metabolism and governance.

6.1. Smart Infrastructure

In relation to smart infrastructure, the prime focus is aimed not only at making the old quarter of Port Louis a tech-savvy area in terms of Information Technology (IT) industries, but also moving towards state of the art smart city processes. Carter [41] proposed three main focus areas for the processes behind an ICT-driven urban regeneration, based on being inclusive, innovative and sustainable:

(a) Digital inclusion: to not only increase access to ICT, but also to popularize and promote ICT knowledge. Such a theme is being proposed in the URS and APZ where knowledge transfer from foreigners to locals is being highly incentivised.
(b) Digital industries: to build upon the highly effective energy and communication grids of Port Louis to lead as a community of digital industries. This requires consequential financial input, which is predicted to be generated within the first few years of adopting the URS (Figures 13–17).
(c) Digital innovation: to promote a smart approach to all facets of city life including the governance and cultural aspects outlined below, as well as the metabolism aspects of transport, energy, water, waste management, as well as governance issues such as disaster monitoring and control within a safe, resilient and sustainable environment.

This will promote better management of resources and solving parking and transportation issues in Port Louis [9,42]. For example, it is possible to use new public transport systems like the Trackless Tram with local shared mobility systems [43–45]. The literature points out the essential role that IT can play in regenerating and even increasing competitiveness and business attractiveness for a city [41,46,47]. Fiscal incentives have been provided in the URS that encourage innovation through ICT along with smart management solutions. Moreover, digital infrastructure as showcased by Allam and Newman [10] can be an enabler of other urban dimensions that aim at economic, sustainable and cultural regeneration.

6.2. Culture

UNESCO [48] extols the potential of culture-led urban rejuvenation through several key entry points of all of the 17 SDGs (Sustainable Development Goals). Culture is at the core of urban rejuvenation [48]. Old city urban fabric has the structural appeal necessary for cultural heritage due to its architectural character and history [49].

In terms of built heritage in Port Louis, the low rental price due to the Landlord and Tenant Act is one aspect of the business environment that has been an administrative dilemma for the governing bodies [31]. To cater to this, the URS provides for an exemption from the Landlord and Tenant Act in the APZ. An increase in property rents in the heritage district will provide for a better income flow for the restoration of buildings having a rich cultural significance. Emerging cities have long been struggling to balance out economic development and sustainability [50], but culture can bridge the gap between these two dimensions or city regeneration [51]. Bertacchini and Re [52] highlighted the laudable potential of culture-led regeneration of Port Louis through its urban heritage. These authors postulated that the capital city of Mauritius can adopt local economic development planning to tap into the rich economic potential of cultural and urban heritage. It is further highlighted that such an approach merges well with both top-down and community-based development strategies.

Moreover, the URS caters to setting up creative and cultural industries, which is expected to be a highly consequential economic contributor [51]. A report by EY [53] supports this claim by showing that the sales of digital cultural goods exceeds that of physical cultural goods, thus showing the economic potential of infusing culture with IT, while touching on a much wider audience. This expands culture to the creative cultural industries, an industry worth USD 2.3 trillions in revenue per year, and 29.5 million jobs worldwide.

In addition, the provision for crowdfunding, previously restricted in Mauritius as part of the 'Public Collection Act', will encourage artists to source funding from the public to support their activities. Such an approach will promote liveability and liveliness in the city of Port Louis. Three such artistic events have already been trialled with outstanding success by the 'Porlwi organisation through their three events: Porlwi by Night, Porlwi by Light and Porlwi by Nature [54]. The smart urban regeneration framework proposes to bridge the gap between economic development and sustainability by focusing also on green industries and a rigorous control of urban metabolism, all aimed at promoting the liveability within the boundaries of Port Louis.

6.3. Metabolism

Grafting of ICT within development projects associated with solar energy, water and energy efficiency, shared battery systems and shared Electic Vehicles -Automatic Vehicles mobility systems can now make new urban development fit within the structures of the old quarter [55,56]. Such ICT includes block chain software for shared services, sensors for monitoring consumption and systems' control for managing flows of resources. This can also promote better management of the city's resources [57] and enable lower cost energy, water, waste and transport services, i.e., higher liveability. This will be particularly important as one hallmark dimension of a smart city is enhanced liveability, which is closely associated with the sustainability of the city [58,59]. Allam [39] highlights that this is achievable through understanding of urban metabolism for Port Louis.

The URS further calls for refurbishment and construction of new buildings, renovation of public infrastructure while promoting green mobility (Figure 11). These major projects will bring economic growth and are thus expected to increase the flow of materials within the APZ of Port Louis; this input, from a metabolism perspective, must not undermine the call for sustainability, so demonstrating low metabolism through ICT support will be high on the agenda for business, government and the community. To such an end, there is a need to integrate social, health and economic indicators into the scheme for urban regeneration as proposed by Kennedy et al. [60]. Moreover, it is essential to consider the impact of materials' flow on the ecological economic system of Port Louis. An assessment of energy needs to be included, as well as a circular pattern of urban metabolism within a sustainable milieu [61]. Newman's extended metabolism model proposes a thorough study of the dynamics of settlements in terms of transport, economic and cultural priorities [45,62]. Further to this, Shahrokni, et al. [63] called for integration of 'smart urban metabolism', which offers higher resolution as citizens and city officials can get feedback on their choices.

The transport and economic drivers, as being proposed in this URS, require adequate infrastructure and governance systems [45]. This highlights the need for a rigorous governance guideline for the whole redevelopment process [64–67]. Furthermore, the URS also caters to housing units in the city, which is expected to reduce vehicular transportation, as people shall live and work in the same place [68,69]. Overall, the URS is expected to promote sustainable development while increasing liveability, but the core of such a feat lies within proper governance.

6.4. Governance

The application of the urban regeneration scheme in an APZ will need its own delivery authority to enable all factors to be brought together. A good example of such an authority is the Barangaroo Delivery Authority (BDA) in Sydney, which enabled the regeneration of an old port area adjacent to the Sydney CBD. It was structured to provide full representation from community and private interests, as well as government and was phased out once completed [70,71]. The BDA was able to achieve a very low metabolism set of buildings along with a strong cultural tourism outcome. For the case of Port Louis, the authority eligible to pilot such an initiative could be the Economic Development Board (EDB), a parastatal entity, which pilots the Mauritian Smart Cities Initiative.

The other governance feature is how to manage the on-going metabolism of the area. Old city urban fabrics have governance structures of low metabolism due to their density and walkability, as well as their transit-friendly opportunities [72]. By combining with ICT, like smart urban management and smart mobility solutions, it can be even better.

The URS promotes key incentives for enhanced investment in renovating public amenities while opening a conspicuous business environment for stakeholders to explore avenues for smart urban management. These core events are expected to create a rebranding of Port Louis from a classically-managed municipality to a smartly managed modern city. For this study, the concept of governance follows Stoker's definition of "a complex set of institutions and actors that are drawn from and also beyond government" [73]. This aligns with the study's aims in terms of private-public partnerships for revamping Port Louis. The literature, however, warns about the potential issue of

urban policy reflecting guidelines of business elites [65,74]. To avoid this ambiguity, the study suggests a regime governance approach that involves a clearly-defined form of collaborative politics [65]. In this type of governance, participants include all stakeholders of the city showcased within the hallmark dimensions of voluntary cooperation based on trust and diplomacy [65]. Moreover, such a governance approach is growth-centred and offers a synergistic cooperation between public and private bodies, which Davies [65] postulated as being able to "achieve otherwise unattainable goals".

This kind of governance approach is facilitated by new smart city technologies such as block chain. The work of Green and Newman has highlighted how citizen utilities can use the block chain to create local shared systems [75]. This approach can be applied to the whole APZ with an on-going management of the core functions of the area.

7. Quantified Results from the Application of the URS

The basis of the econometric model is provided in Appendix A. It sets out how the Smart Urban Regeneration Framework using an Urban Regeneration Scheme applied to an APZ could result in investment and jobs that would bring the old city of Port Louis to life. The quantification exercise was led by the Port Louis Development Initiative (PLDI) in collaboration with the first author.

7.1. Financial Impact

It is estimated that USD 1.22 billions could be generated from investment as a result of the application of the URS. Figure 13 showcases the yearly estimated investment, as well as the cumulative sum. As it was assumed that projects are to start in the next six months from the adoption of the URS, it was noted that by Year 5, sizeable projects are expected to come to fruition, thus highlighting a decrease in investment.

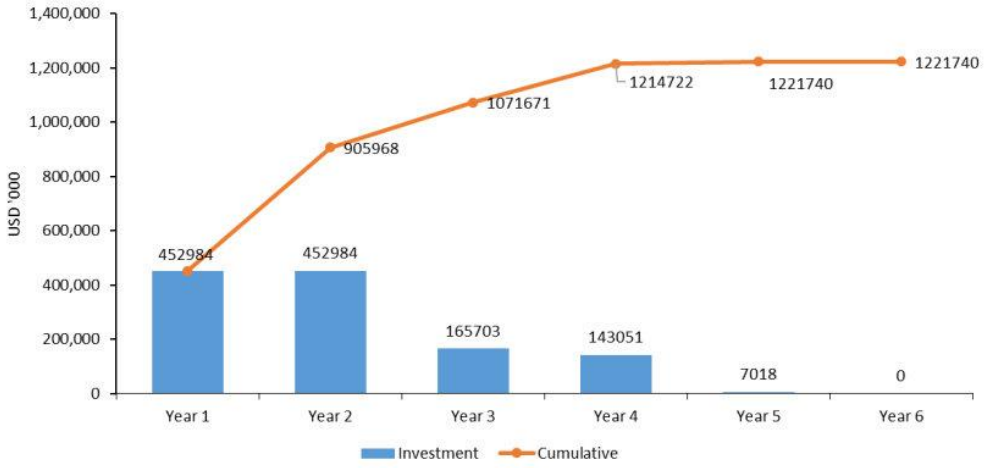

Figure 13. Investment generated.

Public revenue on the other hand is expected to witness an increase as more property space becomes available to host businesses. It is estimated that a total of USD 34 millions could be generated as a result of the URS by Year 6. Figure 14 highlights the yearly and cumulative estimated Value Added Tax [76], income tax and trade fees revenue.

7.2. Business and Jobs' Creation

A total of USD 184 millions is expected to be generated from new business activities with USD 157 millions as turnover in the six-year period. Figure 15 showcases the rental income, turnover from new businesses and the increased economic activity, both yearly and cumulatively.

Nine thousand two hundred and ten permanent jobs are expected to be created as of Year 6. It is observed that Year 6 results in a low figure and corresponds to a stabilisation of the creation of jobs with the creation of business activities. Figure 16 showcases the job creation by year and cumulatively.

Furthermore, it is expected that 94,588 jobs are to be created for the six-year period during construction periods. It is observed the low figures for Years 5 and 6 correspond to the reduced investment in the same period. Figure 17 showcases the yearly estimated job creation by year.

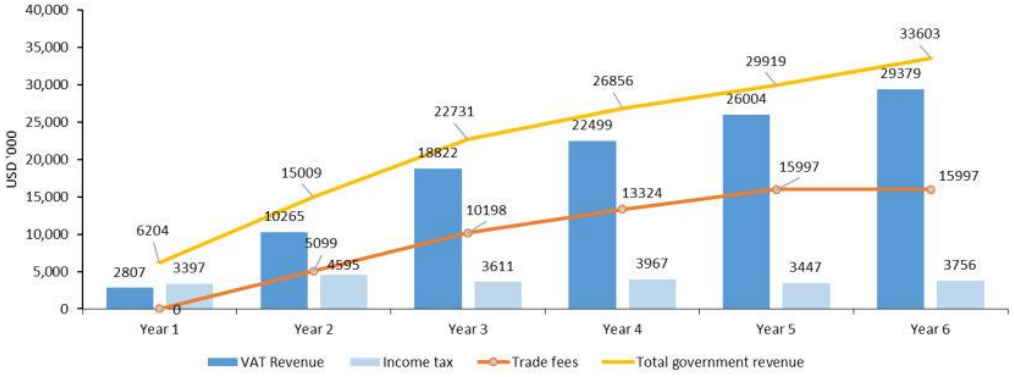

Figure 14. Governmental revenue.

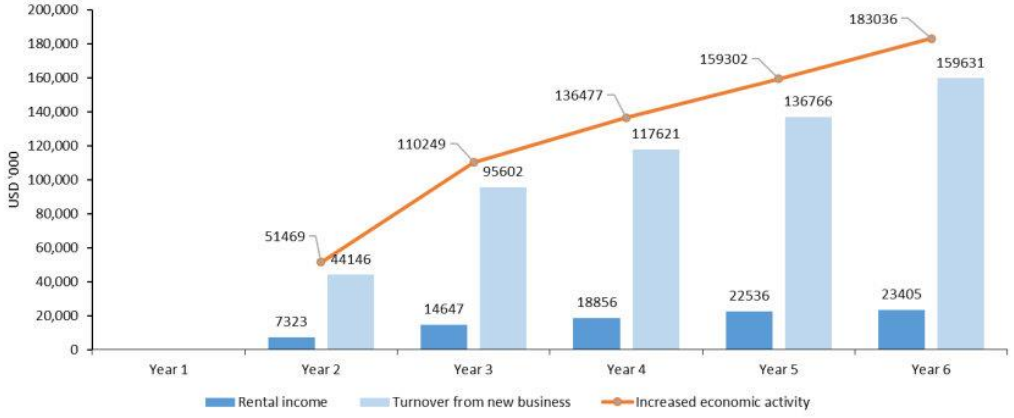

Figure 15. Increased business activity.

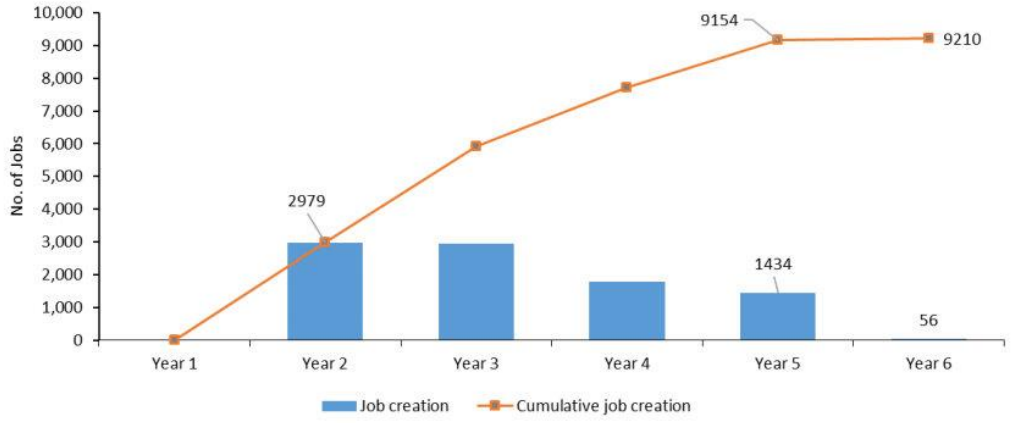

Figure 16. Permanent jobs' creation.

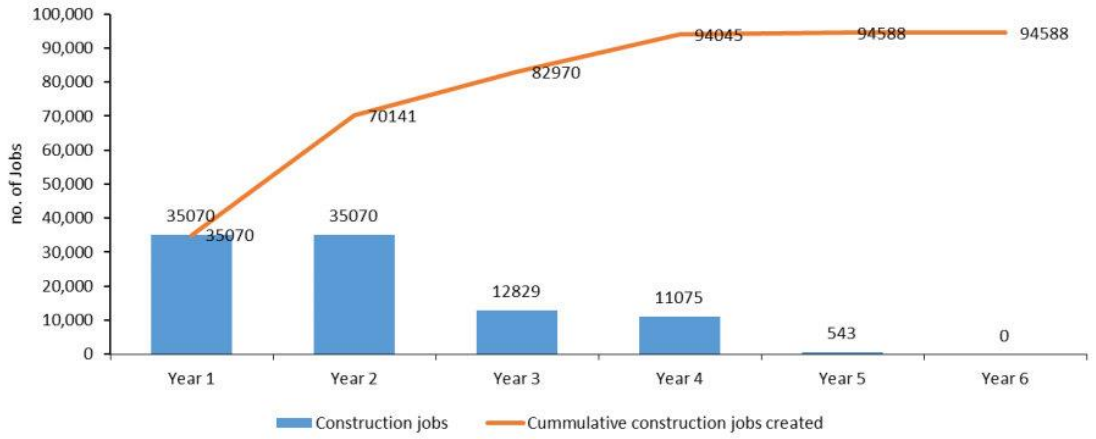

Figure 17. Construction jobs.

8. Conclusions

Urban decay is a potential danger faced by many cities that struggle to cope with the calls of economic attractiveness, liveability and sustainability. Port Louis may face a similar fate following the setting up of new, highly incentivised, smart cities in Mauritius in greenfield sites that are impacting on business investment in the old city. Rather than continuing with the old way of managing the old city, this paper has suggested a new way, based on a focus group of important stakeholders, that suggested how the concepts and technologies of the smart city could in fact be applied to the old city and lead to its urban regeneration.

Fiscally incentivising economic development as an urban regeneration tool is well documented in Mauritius [14,17]. However, incentivising to produce outcomes that respect culture, metabolism and governance using smart infrastructure, is new. Some examples were outlined of how this can be done. As such, to ensure a sustainable, smart and inclusive framework for business, culture and people, an urban regeneration scheme based on a smart urban regeneration framework was proposed for revamping the city of Port Louis through fiscal incentives. The urban regeneration scheme is detailed for an APZ in the old part of the capital city of Mauritius.

The expected outcomes of the urban regeneration scheme can be measured through projected investment gains, business and jobs' creation (as set out in Figures 13–17). The resulting impacts, based on econometric models show promising figures for a six-year period following its implementation. An estimated USD 1.22 billions is expected from investments, while USD 34 millions and USD 184 millions are anticipated for public revenue and from new business ventures, respectively. Moreover, 94,588 construction jobs and 9210 permanent jobs could be created in the same six-year period.

Despite such clear cut positive projections, it remains to be dissected how the actual dimensions interact to promote a rejuvenation and revamping of economic activities in Port Louis under a sustainable setup. It is hoped that the framework developed here will provide the catalyst that speeds up urban regeneration in a sustainable way [75].

This study seeks to inform policy makers about the potential of cities to be regenerated in their old urban fabric by the use of smart city technologies and concepts based on outcomes that enable the city to make the most of its benefits in culture, metabolism and governance. The URS proposal for Port Louis was adopted by the Government of Mauritius and expanded at the national level through the National Budget of 2018–2019. Many other cities with old areas in decline could benefit from such an approach.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

A.1. The Econometric Model

There are econometric models for measuring the impacts of tax incentive policies [77] in relation to their various contexts. However, there are no specific model that responds, in its entirety, to full set of criteria in the modelling for this paper. This is supported by the notable lack of connecting frameworks catering for innovative economic measures and methods [78]. Therefore, two distinct models were applied to various fragments of this study. The results are then combined for interpretation of findings. This approach allows for the containment of data irrelevancy to specific segments if arisen. While the combination of models have their limitations, this approach is supported by literature as it increases forecasting accuracy [79]. The agglomeration economic model [80] and the private construction forecasting model [81] was used to estimate jobs creation and construction & investment generated. Furthermore, the econometric forecasting was restricted to a time frame of 6 years, as longer time frames were shown to involve risks and contribute to inaccuracy [82].

A.2. Assumptions

The econometric forecasting was fed with available statistical data, information from governmental reports and by proprietary data granted by The Port Louis Development Initiative (PLDI). For this exercise, the following assumptions were made.

A.2.1. General

Aside from current activities, all new spending, revenues, profits and jobs created were assumed to be incremental on the basis that expected increasing activities would not have taken place without the URS.

A.2.2. Capital Expenditure for Construction

Sizeable architectural projects that are in development were taken in consideration with the assumption that those projects shall accelerate to benefit from the package of fiscal incentives. The total expenditure was fractured in different categories based on the nature of the investment and the intended use of created spaces. For new constructions, a market rate of Rs 50,000/m^2 was assumed, while refurbishments were tabulated with a figure of Rs 20,000/m^2.

A.2.3. Start of New Constructions

For simplicity, it has been assumed that construction of certain projects shall start in the year 2018. Since the proposal is aimed at the national budget scheduled in June 2018, this provides an assumption of six months, which is deemed reasonable for projects that already possess building permits. It is further assumed that 20% of unbuilt plots in Port Louis would be converted to residential and office spaces.

A.2.4. Occupancy Rate

From estimations of the current market, it was assumed that 15% of all properties in Port Louis are currently unoccupied. This figure was based on expert analysis. Fifty percent of that vacant space is assumed to be renovated as a result of the URS, and only 20% of vacant space is computed for renovation.

A.2.5. Rental Income

The current market rates were factored to calculate the potential income generated by type of space usage. This was further used to model the costs of investment. In addition, due to the upcoming new urban developments in Mauritius and the increasing competition, potential tenants will be tied in lease agreements and will not be able to relocate in the immediate short term. As such, it is assumed that only a ratio of 40% of new space constructed will be occupied by new activities, where the remaining will be occupied by existing activities.

A.2.6. Turnover

The additional turnover and profits to be generated by new businesses and commercial/retail business were based on the ratio of revenue/profits to rental for typical businesses.

A.2.7. Permanent Jobs' Creation

The total number of jobs created from the new businesses (office and commercial/retail) were based on the new surface area occupied by new businesses. As the most common occupancy for new and current economic sectors in Port Louis concerns office and commercial, a figure of one employee for 10 m^2 and 30 m^2, respectively, was used.

A.2.8. Construction Jobs' Creation

The number of construction jobs generated was based on the national spending from the construction sector and the resulting creation of jobs. Due to market fluctuations, the most recent figures of 2018 were used, which generated 56,500 jobs [83]. It was therefore assumed that 2.3 construction jobs shall be generated for every Rs 1 million spent, per annum.

A.2.9. Governmental Revenue

Governmental income was based on the (1) generated VAT on turnover by new businesses; (2) income tax on profits of new businesses and additional demand from construction companies; and (3) trade licence fees based on new businesses and from the increased revenue from existing ones, thus requiring higher categorisation of fees.

A.3. Limitations

The Author Acknowledges Various Limitations Mainly Due to the Broadness of the Study

The first concerns property value as is threefold: (1) There was an inability to quantify the resulting impacts on property value from cultural & artistic manifestations due to arise. While there are numerous studies [84,85] that provide an insight on this, no contextual information as to the metrics are available for the context of Mauritius. (2) The URS provides the opportunity to attract investment in public spaces and assets. Research suggest that this impacts considerably on property value [86,87], however due to local regulations in place and the limitations of attracting private investment for public services and utilities, no considerable investment would result in the next six years. (3) No provision for property depreciation & appreciation was tabulated in this study, and its related impact on property rental was tabulated. This was due to the fact that controlled rental, through the Landlord and Tenant act [23], is imposed in Mauritius, and there are no prior local research on the impacts on the exemption of this law on property value.

The second concerns job creation. While the agglomeration model [80] provides a clear pathway to estimate jobs creation, white collar jobs were removed from the exercise, due to the lack of available statistics and data for clear interpretation.

The third concerns revenue and expenditure. The study estimates the investment to be generated as a result of the URS, research underlines econometric models for predicting the ratio of Foreign Direct

Investment [77]. However, there are no calibrated models to predict the ratio of Local and Foreign investment and the resulting interest rates for either business or state, which ultimately impacts on revenue generation.

For simplicity and unambiguity, the three factors as described above were abstracted from this study.

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CO-AUTHORSHIP STATEMENTS

PUBLICATION 1

15th August 2018

CO-AUTHORSHIP STATEMENT FOR THE PAPER: 'REDEFINING THE SMART CITY: CULTURE, METABOLISM & GOVERNANCE'.

For the purpose of the PhD thesis by Publication of Zaheer Allam; PhD Candidate at Curtin University Sustainability Policy Institute, Curtin University, please find below a co-authorship statement acknowledging the respective contributions of the two authors:

I, Zaheer Allam, contributed 70% of the publication entitled:

Allam, Zaheer and Newman, Peter. 2018. "Redefining the Smart City: Culture, Metabolism & Governance".

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10th April 2018

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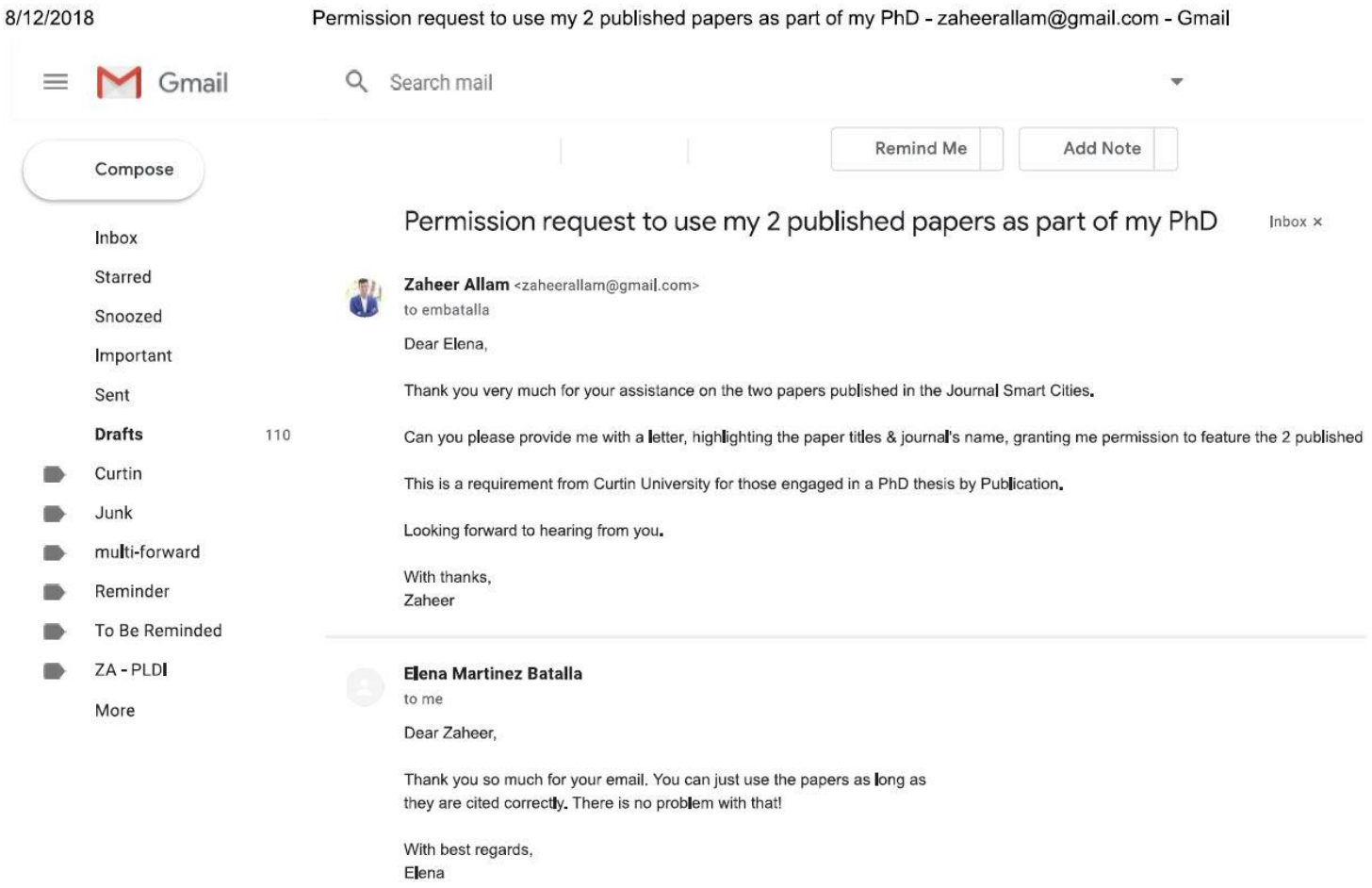

AUTHORISATION FOR REPUBLICATION FOR PAPER 6

5/4/2018 Gmail - Permission request to re-publish IFLA paper as part of PhD

Gmail **Zaheer Allam <zaheerallam@gmail.com>**

Permission request to re-publish IFLA paper as part of PhD

Zaheer Allam <zaheerallam@gmail.com> Wed, May 2, 2018 at 12:55 PM
To: IFLA World Congress 2018 <ifla2018@singex.com>

Dear IFLA congress team,
Dear Jay,

I hope this mail finds you well. I am plan to use the IFLA paper as part of my PhD that is aimed for submission in August. For this purpose I require:

1. A correspondence to grant permission to re-publish my paper for this purpose;
2. The conference proceedings in electronic version.

Can this be arranged? And please advise when will the proceedings shall be available online, and if its possible to receive them ahead of the conference?

With thanks,
Zaheer Allam
IFLA Advisory Circle

5/4/2018 Gmail - Approval

Gmail **Zaheer Allam <zaheerallam@gmail.com>**

Approval

IFLA World Congress 2018 <ifla2018@singex.com> Fri, May 4, 2018 at 10:26 AM
To: "zaheerallam@gmail.com" <zaheerallam@gmail.com>

Dear Zaheer,

The conference committees have approved your request to republish the paper.

Thank You.

Best Regards,

Kwan Zheng Wen, Aden| Project Executive | SingEx Exhibitions Pte Ltd |
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AUTHORISATION FOR REPUBLICATION FOR PAPER 7

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Zaheer Allam <zaheerallam@gmail.com>

Permission to re-publish article from JBU in PhD Thesis

Stefano Serafini <stefano.serafini@biourbanism.org> Wed, May 2, 2018 at 7:34 PM
To: Zaheer Allam <zaheerallam@gmail.com>
Cc: Journal Of Biourbanism Jbu <jbu@biourbanism.org>

Dear Zaheer,

This is to authorize you to re-publish the paper from Journal of Biourbanism VI(1&2/2017):

Zaheer Allam
BUILDING A CONCEPTUAL FRAMEWORK FOR SMARTING AN EXISTING CITY IN MAURITIUS: THE CASE OF PORT LOUIS

as part of your PhD dissertation.

My very best wishes and congratulations,

Stefano Serafini
Managing Editor, Journal of Biourbanism
[Quoted text hidden]

DATA USAGE AUTHORISATION

PLDI
THE PORT LOUIS
DEVELOPMENT INITIATIVE

10th April 2018

Urban Planner
The Port Louis Development Initiative
Dr Ferriere Street,
Port Louis

Dear Zaheer,

For your PhD, you have permission to use the urban strategies of the Port Louis Development Initiative (PLDI).

I wish to highlight to Curtin University and to your supervisory panel, that you yourself have worked for the PLDI and have contributed significantly to building our Urban Strategies, and various studies.

I acknowledge that efforts will be made to reference the source where possible.

All the best,

Gaetan Siew

Chairperson, PLDI

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